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CONTENTS

ORIGINAL PAPERS
The Hand Slit Lamp—Its Functions and Techniques in Office Practice. *Charles C. Turner* 505
The Effect of Spectacle Lenses and Accommodation on the Depth of Focus of the Eye. *Gerald Westheimer* 513
Some Effects of Auditory Stimuli on the Perception of Visual Flicker. *George W. Knox* 520
The Electrical Responses of the Eye. Part II. Optic Nerve Responses of Complex Eyes. *David D. Michaels* 526
The Correction of Unilaterial Aphakia with Corneal Contact Lenses. *Alfred A. Rosenbloom* 536

EDITORIALS
Milestones in Optometric History. *Carel C. Koch* 543
Foundation Membership Drive Now Underway. *William C. Ezell* 546

SPECIAL REPORT
Casual and Syndromatic Analysis. *William F. Garber* 549

CURRENT COMMENTS
Robust Leadership in New York. *Terry Judith Parkins* 552

TRANSACTIONS OF THE ACADEMY 554

BOOK NOTICES
Contact Lens Routine and Practice, by Norman Bier. *V. J. Ellerbrock* 557
Eye Strain, Its Cause, Consequences and Treatment, by V. Brumer. *William F. Garber* 558

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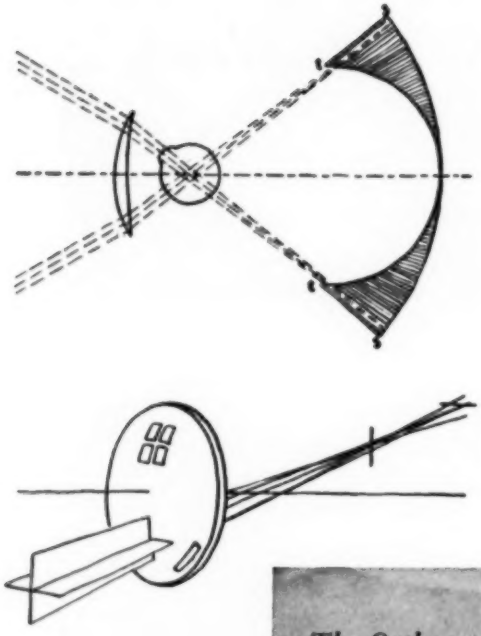

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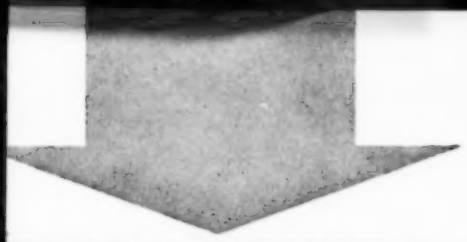

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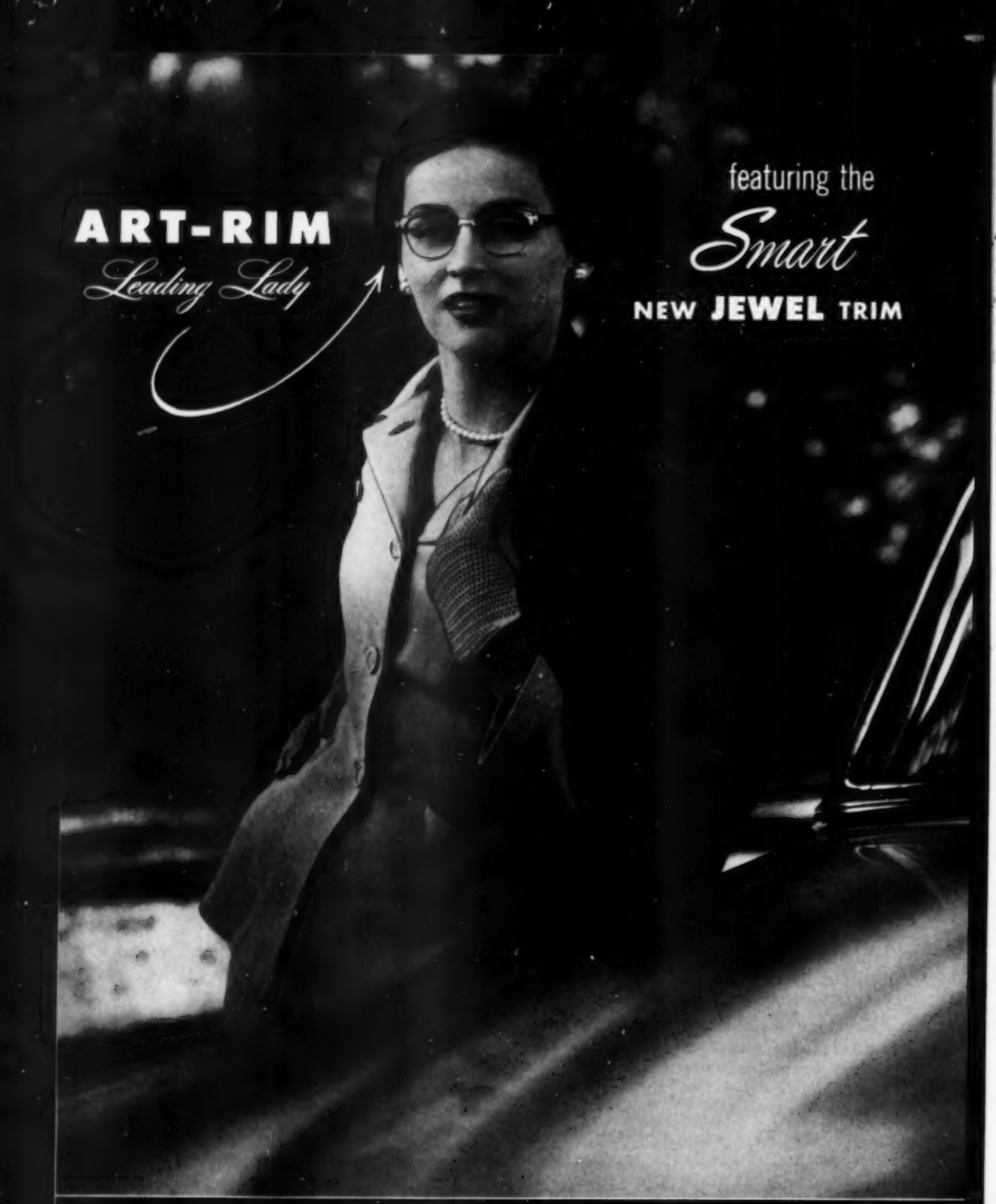

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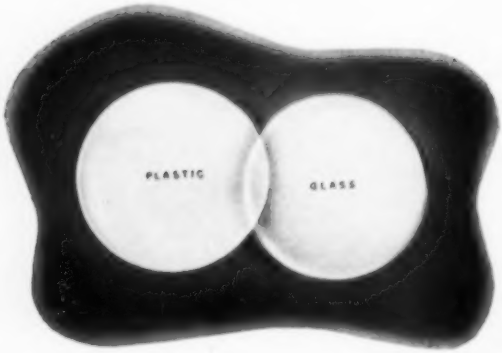

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THE HAND SLIT LAMP—ITS FUNCTIONS AND TECHNIQUES IN OFFICE PRACTICE*

Charles C. Turner†
Quincy, Florida

In the past 25 years the slit lamp has assumed an importance second only to the ophthalmoscope in the observation and diagnosis of eye diseases. Indeed so much progress has been made that the ophthalmoscope has now been largely relegated to fundus observation and the slit lamp has pre-empted most of its functions in the study of the anterior segment of the eye. The slit lamp has become a necessary instrument in routine eye work.

This instrument consists of a brilliant homogeneous narrow band of light projected by an appropriate lens system through the anterior segment of the globe. The structures thus illuminated are observed obliquely with high magnification. Various manufacturers incorporate observation and illumination systems in their instruments that are quite flexible, however, the above description may be regarded as the "hard core" of any slit lamp design.

Two factors have retarded the use of the slit lamp and biomicroscope in optometric practice: (1) The supposed necessity for a dilated pupil. (2) The high cost of the instrument itself.

If one examines without a dilated pupil, the study of the lens is rather limited, however, the value of the lamp is undiminished for other structures. In my experience with undilated pupils, I would say that perhaps 80 per cent of its initial clinical value still remains. Ability to explore the lens with the slit lamp is a positive necessity for the surgeon. It is less important for the non-surgeon if he is skillful with the ophthalmoscope. While mydriasis facilitates examination of the lens, it is not necessary to have a dilated pupil in order to use the slit

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†Optometrist.

lamp in a highly satisfactory manner. Until recently, no hand slit lamp had appeared that could compare favorably with the larger, expensive instruments. In the past two years, several manufacturers here and abroad have corrected this situation. The instrument used in my office and for the purposes of this paper is the Bausch and Lomb Portable hand Slit Lamp, Figure 1, with a 10-X partially fixed monocular

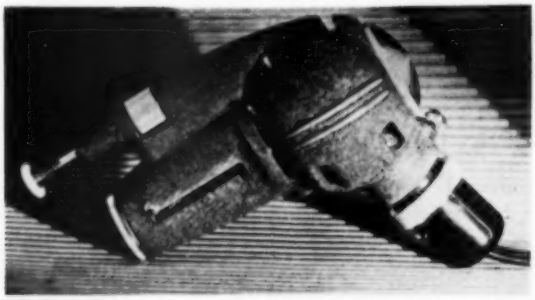

Fig. 1. The hand slit lamp. Bausch & Lomb Optical Company.

magnifying system. This instrument provides the essentials for adequate slit lamp microscopy of the living eye. It provides high illumination, moderate magnification and an adequate field of view. It is relatively inexpensive. (*i.e.*, $80.00 as compared to a $1,000 for the full size slit lamp).

One of the problems that besets the beginner in slit lamp technique is that only one detail of the eye is in focus at one time. Text book illustrations are designed for teaching purposes and consequently are drawn as though the entire anterior segment were in focus simultaneously; clinically this is not true. Only one detail at a time may be clearly seen. It is essential that this difference be kept in mind if the novice is not to become confused and discouraged.

The Methods of Illumination are as follows:

Direct Illumination: Observation of a structure under the direct beam of the slit lamp.

Indirect Illumination: Observation of a structure by reflected light from an adjacent area.

Retro Illumination: Observation with light reflected from behind the structure to be studied, i. e., a corneal scar with light reflected from the anterior surface of the lens or iris.

Oscillation: Observation under an oscillating beam of the slit lamp caused by moving the lamp to and fro with the hands.

Zone of Specular Reflection: A method not well suited to the

hand slit lamp. Its chief use is that of inspecting the corneal endothelium by observation directly into the reflection of the arc of the slit lamp bulb upon the cornea.

Sclerotic Scatter: The least important of the various illumination methods. It consists of observing the desired structure with light reflected from the sclera.

These various methods of illumination are quite confusing to the beginner in slit lamp microscopy. It is most important to remember that in clinical practice they are used simultaneously and after a time, automatically. These individual types of illumination do not have the significance in daily practice that the space devoted to them in text books would indicate.

In this short paper, I will not go into the rare and unusual conformations brought to light by good slit lamp technique. Rather, I will confine my remarks to those conditions which have the greatest significance in optometric office practice and most especially to those pathological conditions that require prompt and early referral. Most particularly we shall enumerate certain conditions that cannot readily be seen or diagnosed by any other technique. We shall omit most conditions that can be made obvious by the ophthalmoscope and the pen light.

The examination technique with the hand slit lamp is very simple. The lamp should be pre-focused. The patient should be seated with the head tipped back, looking toward the ceiling. A head rest is desirable. Figure 2. I use the lamp with the narrowest possible slit

Fig. 2. Slit lamp in position and ready for use. Bausch & Lomb Optical Co.

and with the focusing device in the full forward locked position. With the lamp focused and the patient readily accessible, the forehead rest is placed low on the patient's forehead. The lamp can be completely controlled with one hand and is focused primarily by a screw adjustment in the lamp's forehead rest, and by tipping and turning the instrument itself.

The normal appearance of the anterior segment of the eye during examination with the slit lamp under a magnification of 10-X is as follows:

We are presented with a narrow brilliant beam of light that crosses the anterior segment of the eye obliquely. This beam illuminates the following structures:

The Anterior Corneal Epithelium: Appears as a brilliant narrow streak in the beam of the slit lamp. Upon oscillation of the beam, the epithelium should be clear, unmarked, and regular.

The Stroma: Appears as a wider, less brilliantly illuminated band in the beam of the slit lamp adjacent to the bright anterior corneal line. The stroma should be regular, unmarked, and somewhat dull in appearance.

The corneal endothelium, Descemets' membrane, and Bowman's membrane, cannot be seen in the normal eye with the hand slit lamp.

Anterior Chamber: Appears as a relatively unilluminated, empty space in the beam of the slit lamp, between the illuminated corneal stroma and the illuminated anterior surfaces of the iris and lens.

The Iris: Presents an enormous variation of anatomical detail in different subjects. Without going into detail, the iris presents its crypts, stroma, the pupillary fringe of pigment, and the collarette. The collarette is not visible in all subjects.

The Lens: This appears as a moderately well illuminated, thick, nonhomogenious area in the beam of the slit lamp at the pupillary aperture. The normal lens presents faintly marked zones of discontinuity, beginning with a relatively bright reflex at the anterior capsule and extending backward to the posterior capsule. By oscillating the slit lamp, the anterior and posterior Y's may be seen.

The Vitreous is optically empty and is rarely seen with the hand slit lamp.

ANTERIOR SEGMENT ABNORMALITIES

The Abnormal Cornea. Opacity: Corneal opacities, depending upon their optical density, vary in appearance from a very light translucent gray to a dense white. With the slit lamp, we can accurately estimate the involved area, the depth of the involvement in the corneal

tissue, and by observing the surrounding area for edema and vascularization, estimate the activity and severity of the lesion. Along this line, staining of the cornea with fluorescein 2 per cent will determine whether or not the corneal epithelium is intact. In general, the age, severity, and extent of corneal disease processes may be estimated from the appearance of scarring, edema, vascularization, and fluorescein staining.

Vascularization: We understand very little about the causes of vascularization in corneal tissue. Classically, it appears in trachoma and in interstitial keratitis. However, vascularization may appear as a result of any corneal inflammation or injury. In the beam of the slit lamp, new vessels in the cornea appear to originate in sheafs and grow from the periphery inward. These new vessels, particularly in the early stages, should not be confused with the normal limbal blood vessel loops. These loops do not extend more than one millimeter inward from the limbus.

Keratic Precipitates: These discrete deposits on the posterior surface of the cornea are difficult to see with the ophthalmoscope and even more difficult to localize. When found, they are strong evidence for anterior uveal disease. In the oscillating beam of the slit lamp, fresh keratic precipitates appear as discrete, colorless, whitish, gray particles, usually in the lower third of the cornea about one quarter millimeter in diameter. Old keratic percipitates become pigmented or may be completely reabsorbed. The early and prompt observation of these particles constitutes a prime clinical reason for using the slit lamp on every patient. These particles may appear whenever the protein content of the aqueous rises as it usually does in anterior uveitis.

Aqueous Flare: This phenomenon is related to the appearance of keratic precipitates, in that both depend upon an increased aqueous protein content. Both may be our earliest indications of anterior uveal disease. Neither flare nor keratic precipitates can be readily distinguished with the ophthalmoscope. Both are highly important, early evidence of anterior uveitis. To properly evaluate this condition, the beam should be focused sharply in the anterior chamber. One half of the slit image should rest upon the iris and the other half upon the lens. We may then compare the appearance of the iris section of the beam with the lenticular section of the beam in the anterior chamber. Flare, if present, will be observed in the lenticular section of the slit lamp beam. Under a magnification of 10-X, flare appears as a faintly foggy phenomenon that renders the sharply focused beam of the slit lamp slightly indistinct. When this appears in a normally clear and optically empty anterior chamber, we have a sound clinical basis upon which to conduct

a thorough going search for uveal disease. This phenomenon once observed cannot be disregarded until accounted for. Either keratic precipitates, or flare, alone or together, constitute an adequate basis for ophthalmological consultation. Flare and keratic precipitates may be found in cases of posterior uveitis, choroiditis, or chorioretinitis, but are less frequent and their mode of formation less clearly understood.

Foreign Bodies: On the cornea these appear as interruptions in the normally smooth corneal surface. Their depth may be accurately estimated with the oscillating beam. Their presence, or absence, in a given case may be determined with certainty. Their age can be roughly estimated from the ring of rust in some cases of metallic foreign bodies or a circle of whitish-gray corneal tissue surrounding most foreign bodies that have been embedded in the cornea for more than 24 hours. Accidental removal of some corneal epithelium either from injury or from rubbing the eye to free it from a non-imbedded foreign body can result in a foreign body sensation by the patient. Corneal lesions such as this can be diagnosed or eliminated by the use of fluorescein two per cent and the slit lamp.

Corneal Dystrophies: A rather meaningless term used to classify the following corneal conditions whose origin is unknown and whose treatment is unsatisfactory. These are, Conical cornea; familial keratitis; marginal degeneration of the cornea; band-shaped opacity, and Fuch's epithelial dystrophy.

We will consider here only conical cornea. Cases of conical cornea present to the slit lamp a series of colorless crisscross streaks and irregular striae in the corneal substance and a very faint distribution of brown-yellow pigment, tending to be circular, but usually incomplete. The pigment, if present, will be found near the apex of the cornea.

Anterior Chamber. Flare has been discussed above. One of the prime values of the slit lamp is an accurate determination of the depth of the anterior chamber. This bit of reliable information is a welcome addition to our rather meager number of hard clinical facts in glaucoma. The depth of the chamber is that unilluminated distance between the posterior surface of the cornea and the anterior surface of the iris and lens.

The Iris. The minute anatomy of the iris is made readily visible with the slit lamp. However, most iris injury and pathology can be readily observed without recourse to this instrument. Of chief interest, flare and keratic precipitates have already been mentioned. Posterior synechiae may be observed and studied in detail where they exist. The occasional case of adherent leucoma is an interesting, if not crucial, slit lamp study.

Persistent pupillary membrane is a normal, common, and interesting structure that is revealed most readily with the slit lamp. This embryonic tissue is observed as a series of colorless, very thin strands, waving about in the anterior chamber and attached to the inner third of the iris. The neophyte must be alert lest he confuse shadows from the patient's eye lashes with this harmless structure.

The Lens. From the standpoint of the optometrist, the study of the lens can sometimes be more rewarding with the ophthalmoscope than with the slit lamp. With the slit lamp lenticular opacities are illuminated directly. Thus, they appear as white, grayish white, or crystalline areas in the lens substance. In a lens with widespread opacification, the entire lens may appear grayish white, or even milk white, under the beam of the slit lamp. This is a considerable contrast to the appearance of these opacities with the ophthalmoscope where they appear as black dots against a red background. We will discuss briefly here only two types of cataracts that are especially revealing with the hand slit lamp.

Traumatic cataract: Appears usually as a monocular condition with a history of injury on or about the head. Upon examination with the slit lamp, the lens reveals a very white opacity that fills the entire pupil.

Nuclear cataracts: The earliest sign of this opacity is a deep seated golden yellow glow emanating from the posterior ⅓ of the lens. This color phenomenon is striking and unmistakable. Later opacification may be observed to occur in the lens nucleus itself. However, not all patients who display this particular lenticular golden glow develop nuclear opacities.

A note on the anterior capsule: Frequently, brown pigment granules will be noticed in the direct beam of the slit lamp upon the anterior capsule. These granules can be entirely normal. Their discovery, however, should provoke an inquiry to the patient regarding a possible history of iritis or an iridocyclitis.

General Remarks: The slit lamp is useful in eliciting from the patient certain omitted facts from his eye history such as old and well healed inflammations and old foreign bodies. It is this writer's opinion that some patients omit these items from their routine histories intentionally in order to test the diagnostic acumen of their eye doctor. Proper use of the slit lamp can do much to reveal these forgotten, or omitted, experiences. Furthermore, this instrument will frequently reveal the reasons for sub-normal acuity in the presence of an adequate refraction.

In busy offices a cumbersome instrument, no matter how valuable, is often used insufficiently. This has been true with some previous models of the large slit lamps. The modern hand slit lamp, while it lacks the capabilities of the larger models, is a simple, and convenient instrument to use from the standpoint of both the doctor and the patient. Slit lamp studies can now easily be done routinely on all patients.

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ABSTRACTS

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A number of papers on modifications of the Zeiss-Nordenson retinal camera for obtaining fundus photographs in color have appeared in recent years. However, the above papers were justified on the premise that a high-speed flash tube is used to provide the light and, consequently, has advantages over any modification heretofore described.

These papers provide a description of a high-speed flash tube adapted to the Nordenson retinal camera, so that the fundus of the human eye can be photographed in color. The high speed flash eliminates the usually deleterious effect of blinking and eye movements. Special electronic circuits are needed to provide a flickering light from the same flash tube to enable the operator to adjust and focus the camera. Ektachrome film is used and this is over-developed to gain equivalent exposure. For the fundus photographs this apparently results in no loss of color relationships.

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THE EFFECT OF SPECTACLE LENSES AND ACCOMMODATION ON THE DEPTH OF FOCUS OF THE EYE*

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The depth of focus of the eye is the range of object distances over which clear vision may be obtained for a given focus adjustment of the eye. It is capable of theoretical study on the basis of first-order optical imagery, but such a treatment ignores many other factors entering into a visual acuity measurement.

The geometrical approach adopted here, however, while still one of the first order, contains an arbitrary parameter which includes these factors. It has been possible to relate this parameter to an experimental study of the depth of focus and thus a scale factor has been found which allows the expression in absolute units of the depth of focus of the eye for a given set of practical conditions.

Some simplifications have been introduced in the calculations to retain the formulation within manageable complexity. The spectacle lenses are taken to be thin, and a schematic eye is used in which the pupil is assumed to lie in the principal plane. No distinction is made between the sizes and positions of the actual pupil and the entrance and exit pupils.

The object of this paper is to study the effect of viewing distance, accommodation, and power of the spectacle lens worn on the depth of focus of a given eye. Hence these simplifications do not seriously detract from the general validity of the approach adopted here.

In Figure 1 let M be the position of an object at a distance s in front of the spectacle lens. The lens is of power F and forms an image of M in N, the far point of the eye in its accommodated state. Let S be the reciprocal of s, and S' the reciprocal of s', the distance between the lens and the far point.

The usual first-order object/image relation holds:

$$S' = F + S. \tag{1}$$

Note that the position of the far point of the eye depends on the spectacle ametropia K of the eye in the unaccommodated state and the

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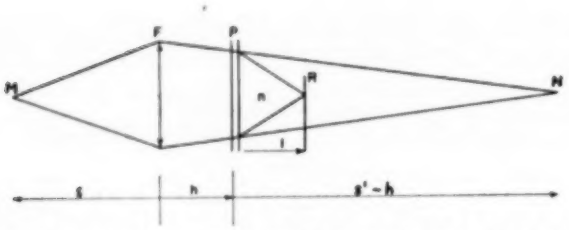

Fig. 1. Formation of image of an object M in the far point N of the eye by a spectacle lens of power F.

accommodation A in use at the time. This is expressed in the following formula:

$$S' = K - A, \tag{2}$$

where K is in diopters and positive in the case of hyperopia and negative in the case of myopia, and where A is the accommodation in the spectacle plane in diopters, always taken positive.

The image N as formed by the spectacle lens is further imaged by the optical system of the eye, P, on the retina, R, according to the formula

$$L' = P + L, \tag{3}$$

where L is the reciprocal of l, the distance between the far point and the principal point of the eye, and where $L' = n/l'$, l' being the distance between the principal point of the eye and the retina and n the refractive index of the vitreous.

The simplest case, of course, is that of the unaccommodated eye which is strictly corrected by a spectacle lens so that the image of the object M falls in the far point of the eye. In this case $S' = K$, since A in equation (2) is zero. In general, however, S' will always be used throughout this study in the meaning of equation (2), i.e., that of the algebraic difference between the spectacle ametropia and the spectacle accommodation.

Note also that, from equations (1) and (2),

$$F - K = -S - A, \tag{4}$$

which states that the near addition $F - K$, i.e., the difference between the spectacle lens power and the spectacle ametropia, is the algebraic difference between the dioptric exquivalent of the object distance and the accommodation in use. It is to be noted that under the sign convention in use here, S is a negative quantity for real object distances.

From equation (1) we obtain

$$dS' = dS, \tag{5}$$

where dS is the dioptric equivalent of a small change in object position

at M and where dS' is the dioptric equivalent of the conjugate small change in the position of N.

Similarly, from equation (3) we obtain

$$dL' = dL, \tag{6}$$

with a similar interpretation of the meaning of dL and dL'.

From Figure 1 it follows that $l = s' - h$ which in the reciprocal notation becomes

$$L = \frac{S'}{1 - hS'}, \tag{7}$$

from which we derive by differentiation

$$dL = \frac{1}{(1 - hS')^2}\, dS'. \tag{8}$$

Combining equations (5), (6) and (8) we finally obtain

$$dS = (1 - hS')^2\, dL'. \tag{9}$$

Since $L' = n/l'$ and $dL' = -n\, dl'/l'^2$, this finally yields

$$dS = -(1 - hS')^2 \frac{n}{l'^2}\, dl'. \tag{10}$$

The formation of a blur circle on the retina is illustrated in Figure 2. The assumption is made that the exit pupil of the eye coincides with the

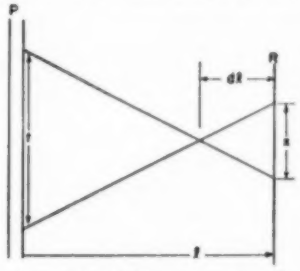

Fig. 2. Formation of a blur circle of diameter x on the retina R when the pupil diameter is t.

posterior principal plane of the eye at P. The size, x, of the blur circle is given by the equation

$$\frac{x}{t} = \frac{dl'}{l' - dl'} = \frac{dl'}{l'} \text{ appr.}$$

where t is the diameter of the pupil. Substituting in equation (10) we obtain

$$dS = -(1 - hS')^2 \cdot \frac{n}{l'^2} \cdot \frac{l'x}{t}$$

$$= - \frac{n \cdot x}{l'} \cdot \frac{1}{t} \cdot (1 - hS')^2. \qquad (11)$$

It is to be noted that nx/l' is the angular extent of the retinal blur circle at the nodal point of the eye in radians. Denoting this quantity by c, equation (11) simplifies to

$$dS = \frac{c}{t} (1 - hS')^2. \qquad (12)$$

This formula relates dS, which is half the extent of the depth of focus in object space in diopters, to

c the angular extent of the permissible blur circle at the eye in radians,

t the pupil diameter in meters,

h the distance between the principal point of the eye and the spectacle lens in meters (taken positive), and

S' the dioptric equivalent of the distance between the spectacle lens and the far point of the eye in diopters, i.e., the expression given by equation (2).

Since a blur circle of size c radians may be produced by the actual image of the object being either in front of or behind the retina, the zone of clear vision will extend a dioptral distance dS either side of the object. If the object is at a dioptral distance S in front of the spectacle lens, the range of clear vision will extend over a zone z given by

$$z = \frac{1}{S - dS} - \frac{1}{S + dS} \qquad (13)$$

where z is in meters when S and dS are in diopters.

It is to be noted that the expression for the depth of focus given in equation (12) does not contain the object distance explicitly. Hence it can be used to express the total depth of focus, $2dS$ (in diopters), irrespective of the actual object distance about which it will eventually be projected. In other words, the depth of focus, when expressed in diopters, does not depend on the object distance even when the ametropia and accommodation is taken into account.

Reese and Fry[1] have measured the visual acuity of an atropinized eye with a 4 mm. artificial pupil with a range of positive and negative spherical lenses. Using the ranges of lens powers within which visual acuity remained at the 20/15, 20/20, and 20/30 levels respectively and substituting in equation (12), the following values for c are obtained:

20/15 Visual Acuity $c = .0005$ radians $= 1.7'$
20/20 Visual Acuity $c = .0015$ radians $= 5.2'$

20/30 Visual Acuity $c = .0030$ radians $= 10.4'$.

With this information the accompanying two graphs have been drawn (Figures 3 and 4). Here, dS, which is half the depth of focus

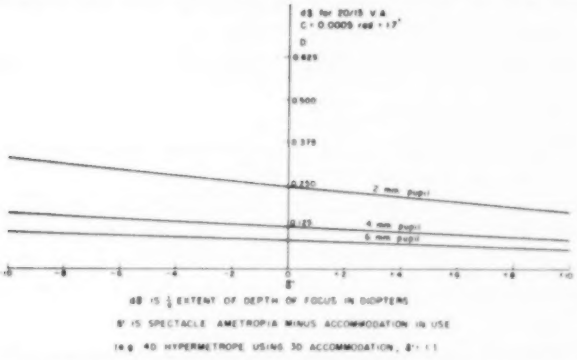

Fig. 3. Graph giving the half extent dS, of the depth of focus for 20/15 visual acuity in diopters as a function of S', the difference between spectacle ametropia and accommodation, and the pupil diameter.

in diopters, is given as a function of S' for various pupil sizes. S' is defined by equation (2) and is found by subtracting the amount of accommodation in use from the spectacle ametropia.

Thus for a 3 D. myope using 2 D. accommodation, $S' = -5$ D., and for a 10 D. hyperope using 3 D. accommodation, $S' = +7$. D. The former case would require a —2 D. lens for viewing an object at 33 cm. and the latter case a +10 D.

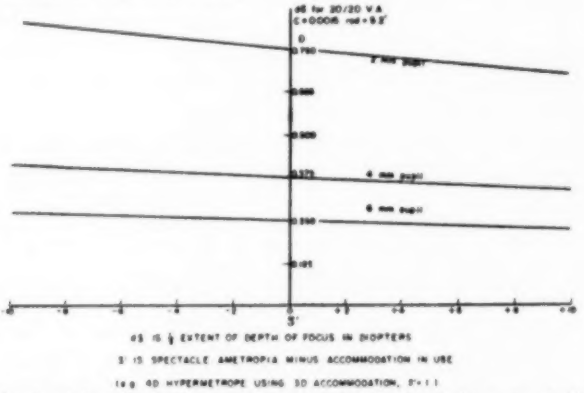
dS for 20/20 V.A.
C = 0.0006 rad = 2.1'
D
2 mm pupil
4 mm pupil
6 mm pupil
S'
dS IS ½ EXTENT OF DEPTH OF FOCUS IN DIOPTERS
S' IS SPECTACLE AMETROPIA MINUS ACCOMMODATION IN USE
e.g. 4D HYPERMETROPE USING 3D ACCOMMODATION, S' = +1

Fig. 4. Graph giving the half extent, dS, of the depth of focus for 20/20 visual acuity in diopters as a function of S', the difference between spectacle ametropia and accommodation, and the pupil diameter.

Two examples will illustrate the use of the graphs.

Example 1. A 4 D. hyperope is an absolute presbyope and wears trifocal lenses with a +1 D. intermediate and a +2 D. near addition. Assuming that his pupil remains constant at 4 mm. what are his ranges of clear vision for 20/15 V.A.?

From Figure 3, $dS = .11$ D. for $S' = 4$ D. and a 4 mm. pupil size.

(a) Distance portion:

z ranges from infinity to .11 D., i.e., from infinity to 9 meters.

(b) Intermediate portion:

z ranges from $+1.00 - .11$ D. to $+1.00 + .11$ D., i.e., from 112 to 90 cm.

(c) Near portion:

z ranges from $+2.00 - .11$ D. to $+2.00 + .11$ D., i.e., from 53 to 47 cm.

Example 2. An emmetrope can exert 1 D. accommodation in the usual course of his near work. He is wearing a pair of bifocals with a plano distance portion and a near addition of +2 D. His usual pupil size is 4 mm. when his accommodation is relaxed and 3 mm. when he accommodates 1 D. What are his ranges of clear vision for a 20/20 visual acuity?

From Figure 4, $dS = .37$ D. for $S' = 0$ and a 4 mm. pupil size (unaccommodated state) and $dS = .5$ D. approximately for $S' = -1$ and a 3 mm. pupil size (accommodated state).

(a) Distance portion:

z ranges from infinity to $+1.00 + .5$ D., i.e., from infinity to 67 cm.

(b) Near portion:

z ranges from $+2.00 - .37$ D. to $+3.00 + .5$ D., i.e., from 61 to 29 cm.

Except for the range from 67 to 61 cm., this individual will have approximately 20/20 visual acuity from infinity in to 29 cm.

SUMMARY

On the basis of first-order imagery, a general formula is derived expressing the depth of focus of the eye in terms of the ametropia, accommodation, eye-spectacle lens separation, the diameter of the pupil and the diameter of the retinal blur circle. The values of the latter are related to visual acuity by the use of experimental data of Reese and Fry.

In this manner it is found possible to draw graphs relating the depth of focus for a given acuity to the ametropia, accommodation, and

pupil size. When expressed in diopters, the depth of focus is independent of object distance.

Examples are given of the application of the graphs in multifocal lens calculations.

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ABSTRACT

THE CHALLENGE TO MEDICAL EDUCATION IN THE SECOND HALF OF THE TWENTIETH CENTURY. Sir Lionel Whitby. British Medical Journal. August 29, 1953. Pages 451-454.

"The challenge to our universities and medical schools is a simple one. Are we preparing our students at least to grasp the principles behind all this scientific work? Does the student leave the university with an understanding of the methods of science and with some knowledge of its history? The doctor of the future will have to be grounded more firmly in the basic sciences than was the student of 20 or 30 years ago, otherwise he will not be prepared to meet the challenge of advancing knowledge which is making medicine a more complex science. And here at once we come up against a difficulty. Because of the length and the ever-increasing complexity of medical studies university authorities ask that the boy at school shall have passed his first medical examination in the basic sciences of chemistry, physics, and biology before he enters the medical faculty. . . . But there is evidence that there is now some poverty of mind in the finished medical and science graduates because of lack of general education in the humanities, literature, language, history, philosophy, and the arts. There is little doubt that the medical student who is to be a practising doctor should understand the world in which his patients live, and should be able to approach them as human beings with a depth of understanding that can only come from an appreciation of civilized values. We are indeed aware of the obvious dangers of too early specialization in science among those who are going to graduate in science and medicine."

Substitute "optometry" for "medicine" in the above and you also have the problem facing our optometric educators.

CAREL C. KOCH

SOME EFFECTS OF AUDITORY STIMULI ON THE PERCEPTION OF VISUAL FLICKER*

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INTRODUCTION

In a previous report on the subject of visual flicker[1] it was indicated that the measurable critical flash frequency (C. F. F.) could be altered by the attitude of the observer and by the manner in which the instructions were worded. Similar effects of the observer's attitude upon other aspects of perception had been reported by the Wurzburg School of Psychology in Germany.

Another line of investigation by psychologists has dealt with the influence of the activity in one sensory department upon the sensory and perceptual activity in another department. This intersensory influence was pointed out by William James[2] near the end of the last century and a summary of such results was made by George Hartmann[3] in 1935. Von Sheller[4] demonstrated auditory-visual flicker induction but did not make measurements of it. The present paper constitutes a report of two investigations on the measurement of auditory influences on visual flicker.

APPARATUS

The apparatus consisted of two parts, one for the control and measurement of visual flash rates and stimulus characteristics as described in the previous report and the other consisted of a device to produce, regulate, and measure intermittent sound stimulation. A continuous sound stimulation was obtained by the use of an electrically driven tuning fork generator, run by a 6-volt direct current. This instrument gave 1,000 cycles per second, with a loudness of 50 decibels.

The alternating interruption of the sound stimulus was made by an interval timer driven by a variable speed motor which was run on direct current. The speed of the motor was governed by a rheostat. The rheostat varied the speed sufficiently to give an interruption range, or an auditory flash frequency range, of 15 to 30 sounds per second.

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The constancy of the resistance of the rheostat was sufficient to permit the construction of a scale of auditory flash frequencies at the side of the rheostat. The scale contained the following readings for the auditory flash frequency: 30, 27, 24, 21, 18, and 15 sounds per second.

A single-poled, double-throw switch was used so that either a continuous sound of 1,000 cycles per second could be given to the subject by disconnecting the interval timer from the tuning fork, or an intermittent stimulus could be given by keeping the two instruments intact.

The subjects wore a pair of earphones which were connected with the sound source.

EXPERIMENT I—PROCEDURE

Five subjects were used in the first experiment, and a total of 800 CFF readings were taken, 160 for each subject. Each subject went through exactly the same procedure, being presented with simultaneous visual and auditory stimuli. Three subjects used the artificial pupil throughout, while two subjects used no artificial pupil.

Half of these CFF readings were taken during an increase of the visual flash frequency while the other half were taken while the visual flash frequency was being decreased. Each visual CFF reading was taken during one of four auditory situations: auditory silence, auditory fusion, a fine auditory flicker produced by an auditory flash frequency of 30 stimuli per second, and a coarse auditory flicker produced by an auditory flash frequency of 15 auditory stimuli per second. The same number of visual CFF readings were taken under each of these four auditory conditions, making a total of 40 CFF readings for each subject under each of the four auditory conditions. Twenty of each of these groups of readings were taken during the increase of the visual flash frequency, and 20 were taken during the decrease of the visual flash frequency.

The order of these readings for each of the 10 sittings of each subject was as follows: One of the four auditory conditions was arbitrarily selected, and the visual flash frequency was then decreased until the visual CFF was reached. The visual flash frequency was further decreased five units, then increased until the visual CFF was again reached. This procedure was continued with the same auditory condition, until there were four visual CFF readings—two taken during the increase of the visual flash frequency and two taken during the decrease of the visual flash frequency. The same procedure was then carried out in turn during the simultaneous presentation of each of

the other three auditory conditions. The only daily variation consisted in changing the order of presentation of the four auditory conditions.

EXPERIMENT 1—RESULTS

Under the conditions of the first investigation no subject showed any significant effects of auditory stimulation on the visual CFF with or without the artificial pupil. The conclusion would be that auditory stimulation (as here used) does not alter the visual CFF.

Aside from the numerical negative results, subject protocalls indicated that when visual flicker was already present, it became more pronounced when coarse auditory flicker was present. Because of these protocalls, Experiment Two was devised in an attempt to measure, if possible, the increased "pronouncedness" (being more pronounced) of visual flicker, due to the presence of auditory flicker.

EXPERIMENT 2—PROCEDURE

This experimental procedure involved a method of measuring the relative increased degree of visual flicker induced by various degrees of auditory flicker. Three subjects were used, and each went through exactly the same procedure, except that one was instructed to concentrate his attention upon the visual stimulus throughout the experiment, another was to concentrate upon the auditory stimulus, and the third was given no instruction in regard to the direction of his attention. An artificial pupil was used throughout.

Before any readings were taken, the intensity of the visual stimulus was adjusted so that the visual CFF reached 48 flashes per second. Half of the recordings were then made with the visual flash frequency starting at one-third of the CFF, or 16 flashes per second, while the other half of the readings were made with the visual flash frequency starting at one-half the CFF, or 24 flashes per second. The flicker experienced under these two conditions can be designated as follows: fine flicker for the flash frequency of 24 flashes per second, and coarse flicker for the flash frequency of 16 flashes per second. The procedure was the same for each day, with the exception that the order of the readings (fine-coarse or coarse-fine) was reversed on each successive day.

The daily readings for the fine series were made as follows: During continuous auditory stimulation, the light flash frequency was set at 24 flashes per second. The auditory stimulus was then changed to either 30, 27, 24, 21, 18, or 15 sounds per second, any of which increased the degree of the visual flicker while the visual flash frequency remained at 24 flashes per second. The subject was then instructed to alter the visual flash frequency (by a rheostat control) to a speed which

would give him the same degree of visual flicker as was previously present when a non-intermittent sound stimulus and a visual flash frequency of 24 flashes per second was present. Since the intermittent sound increased the degree or coarseness of the visual flicker, the visual flash frequency obviously must be increased in each case, in order to decrease the coarseness of the visual flicker to its original condition.

After this increase of the visual flash frequency, the stimulations were set back to the original starting point, that of a continuous auditory stimulus and a visual flash frequency of 24 flashes per second. The auditory stimulus was then changed to another frequency of the intermittent series (30, 27, 24, 21, 18, 15 sounds per second) and the same procedure was carried out. This procedure was continued until a light flash frequency was picked for each of the intermittent sounds, so that the combined effect of the visual and auditory stimulation gave the same degree of visual flicker as was present when the standard of a continuous auditory stimulus and a visual flash frequency of 24 flashes per second was present.

Exactly the same type of procedure was then carried out for the coarse flicker except that in this case a standard visual flash frequency of 16 rather than 24 flashes per second was used.

The procedure in both coarse and fine readings gave a total of 12 visual flash frequency readings per day, a coarse and a fine flicker for each of the six conditions (30, 27, 24, 21, 18, 15 sounds per second) of the intermittent sound. The same procedure was continued 20 days for each of the three subjects.

EXPERIMENT 2—RESULTS

The curves of Figure 1 give the average readings for each of the three subjects for both fine and coarse flicker. In each curve, the ordinate represents the visual flash frequency, while the abscissa represents the rates of auditory flash frequencies per second. Each point on a curve represents equality of experience in regard to the pronouncedness or coarseness of the visual flicker. In the upper group of three curves, each curve (one curve for each subject) represents all combinations of visual and auditory flash frequencies which gave the same degree of visual flicker as was present with a visual flash frequency of 24 flashes per second, and a continuous sound. In the lower group of three curves (one curve for each subject), each curve shows the various combinations of visual and auditory flash frequencies which gave the same visual flicker as the combination of a visual flash frequency of 16 flashes per second and a continuous sound stimulus.

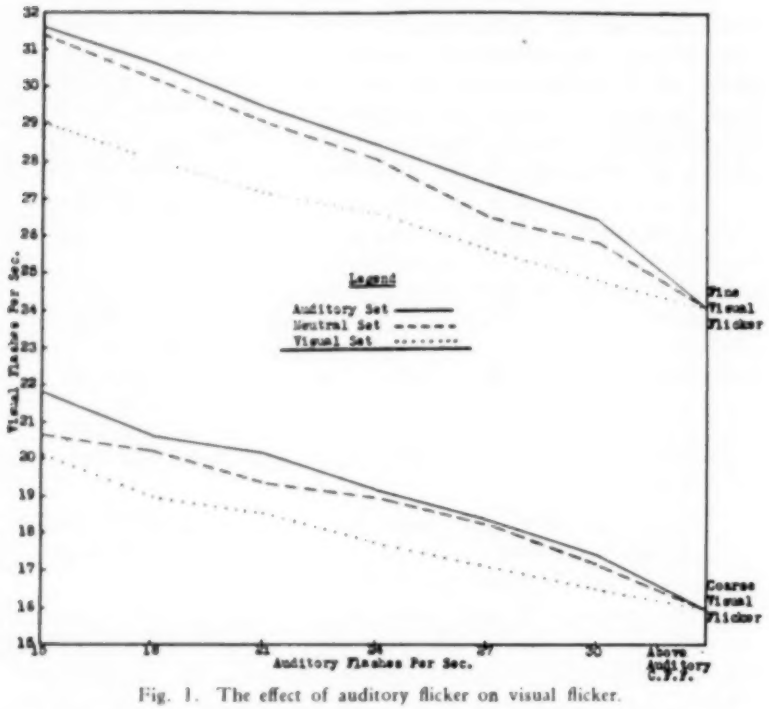

Fig. 1. The effect of auditory flicker on visual flicker.

In each group of three curves, the curve of greatest slope represents the data of the subject who concentrated on the auditory stimulus, while the curve of the least slope in each group, represents the data of the subject who concentrated on the visual stimulus. The curves of the "neutral" subject are intermediate in each case.

CONCLUSION AND DISCUSSION

Although the effects of the intermittent auditory stimulus are not able to induce a visual flicker when visual flicker is not already in existence, the effects of the intermittent auditory stimulation can increase the pronouncedness of the visual flicker, if it is already present.

There was one factor of the second experiment which made the experiment difficult to perform. This was the necessity of dealing with the problem of memory. The subject did not compare two simultaneous perceptions, but rather he was compelled to compare the degrees of flicker of a present perception with the memory of a previous perception. He had to remember how much flicker was present during the

original stimulus, and had to adjust the present intermittent visual stimulus so that the present flicker seemed to be of the same degree as that which was previously experienced. One need only consider experiments of positive and negative time error in psycho-physics, to realize the difficulties and sources of possible error encountered by this comparison of the memory traces with the present perceptual process.

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ABSTRACT

THE CORRECTION OF ASTIGMATISM IN PRACTICE. A. J. Forknall. The Irish Optician. (Dublin). 2.6.12-16.1953.

The author reviews the objective and subjective methods of testing for astigmatism and arriving at the monocular cylinder which seems to best correct the ametropia. He then suggests the following binocular tests, made with fixation at infinity. In cases where strong oblique cylinders are indicated the patient is directed to read the smallest line of test characters and the cylinders are rotated 5 degrees towards the median plane, one clockwise and the other anti-clockwise, to determine whether an improvement in visual acuity is noted. The lenses are then rotated in the opposite direction. The author points out that frequently an improvement in acuity results. Following this technique, the patient is directed to view a vertical line and note whether or not it is tilted slightly. Unless it appears vertical the power of the correcting cyclinder may have to be modified.

The author also cautions against changes in cylindrical corrections in elderly patients who have used the same cylinders at fixed axes for long periods of time. Even with some improved acuity these changes are most difficult for the patient to become adjusted to.

CAREL C. KOCH

THE ELECTRICAL RESPONSES OF THE EYE*

PART II. OPTIC NERVE RESPONSES OF COMPLEX EYES

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Chicago, Illinois

PART II

Adrian and Matthews (1927) recorded the components of the optic nerve discharge from the eye of the Conger Eel (Conger Vulgaris). They used a vacuum tube amplifier and a capillary electrometer. Taking the latent period (or as they later called it, reaction time) of the nerve response as a criterion of excitation, they found that an increase in intensity, duration or area, results in a decrease in the latent period. The three factors are thus, within limits, interchangeable and the end effect is determined by their total product. (Figures 9 and 10). This

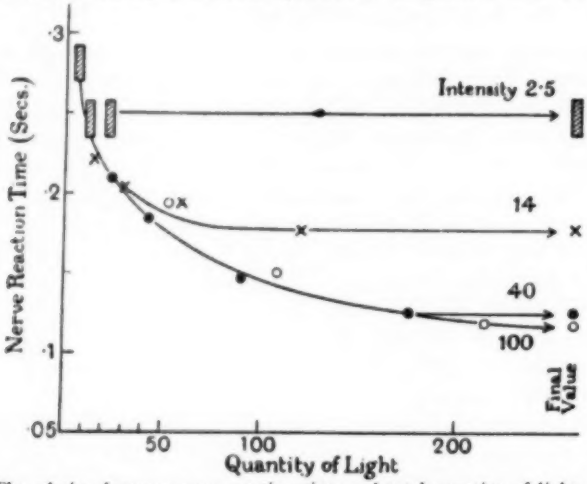

Fig. 9. The relation between nerve reaction time and total quantity of light (intensity X duration X 100). Area was kept constant. The curves show that for short flashes of different intensity the reaction time depends simply on the total quantity of light received by the eye providing the flashes are short compared to reaction time. After Adrian and Matthews, 1927.

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†Optometrist, M.S., Chairman, Department of Biologic Sciences. Fellow, American Academy of Optometry.

Part III, The Electroretinogram, will appear in the November issue.

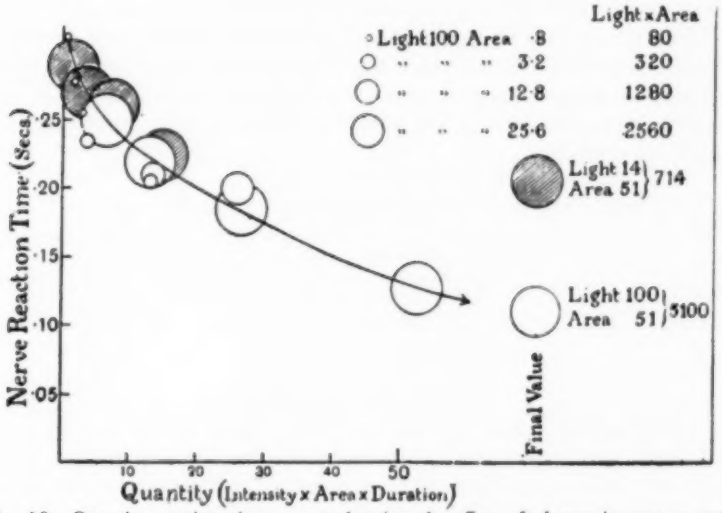

Fig. 10. Quantity-reaction time curves showing the effect of change in area as well as in intensity and duration. Areas are in arbitrary units which varied from .084 to .95 mm. diameter* and are roughly indicated by size of the circles. After Adrian and Matthews, 1927.

* Area 102 corresponds to a retinal image .95 mm. diam.
" 51 " " .57 "
" 25.6 " " .33 "
" 6.4 " " .23 "
" 3.2 " " .17 "
" .8 " " .084 "

inter-relation was found to be approximately valid if the retinal area did not exceed 1 mm. in diameter. Similarly, for a constant intensity and area, there was found an optimal duration at which the stimulus has a maximal effect in shortening the latent period of the discharge. As Adrian and Matthews point out:

> "It is obvious that these facts do not agree with the simple conception of the retina as a mosaic of sensitive points each connected with its nerve fiber and each acting independently of the rest. The shortening of the latent period when the size of the retinal image is increased can only be explained on the assumption of some kind of interaction between the different stimulated points."

In order to determine the nature of this interaction Adrian and Matthews (1928) performed the following experiment. Four small illuminated areas (about 0.22 mm. in diameter) set at equal distances on an imaginary circle 1 mm. in diameter were used to stimulate the retina. The latent period of the nerve response was found to be shorter when the four spots act together than when they act individually. When the diameter of the imaginary circle on which the four spots lie is increased to 2-3 mm., no shortening of the latent period was found between the

four spot and the single spot stimulation. After the minimum separation which results in an unchanging latent period is determined, a drop of 0.01%-0.005% strychnine solution was applied to the retina. The exposure was then repeated and the latent periods re-determined for both the four spots and for a single spot. Table II gives the results of a sample experiment.

TABLE II

Retina Illuminated over Four Areas Designated A, B, C, and D

Area	Before Strychnine Latent Period	After Strychnine (0.01%) Latent Period (12 minutes after application)
A	0.18 sec.	0.31 sec.
B	0.21 sec.	0.32 sec.
C	0.18 sec.	0.37 sec.
D	0.18 sec.	0.29 sec.
A-B-C-D	0.18 sec.	0.23 sec.

After Adrian and Matthews, 1928

The results indicate that although the latent period for the four and single spot stimulation was the same before strychnine, the latent period to the four spot stimulation becomes considerably shorter after the application of strychnine. Since strychnine is known to facilitate conduction at the synapses, the locus of interaction is pulaced in the synaptic layers.

These results are to be contrasted with a later experiment by Graham (1932). He studied the response of the optic nerve of Limulus, whose eye is known to contain no lateral connections. A small point of light was used to stimulate various regions of the retina and the sensitivity of these regions (in terms of the latent period of the response) was measured by use of the micrometer manipulator. When the limits of the most sensitive region had been determined, the aperture of the light source diaphragm was centered on the middle of this most active area. By adjusting the size of the diaphragm and later examining the eye under the microscope, the number of ommatidia stimulated by a given area could be determined. These results are presented in Table III.

TABLE III

Latent Period (second)

Number of Ommatidia	1.0 arbitrary unit of illumination*	0.1 arbitrary unit of illumination	.01 arbitrary unit of illumination	.0001 arbitrary unit of illumination
121	0.080	0.070	0.180	0.485
33	0.075	0.080	0.190	0.575
10	0.072	0.075	0.185	0.490
2	0.072	0.084	0.185	0.490

*1 arbitrary unit — 4500 meter candles at the eye.

The data indicate an unchanged latent period with increased area illuminated although it is directly affected by changes in intensity. It would seem therefore that the latent period of the optic nerve of Limulus, which has no lateral connections, is determined by the fastest acting of the responding sense cells whether these are illuminated alone or in conjunction with adjacent cells.

Using the microdissection technique, Hartline (1938) was able to isolate single fibers of a vertebrate optic nerve. He found that the optic nerve fibers of the frog do not all respond in the same way to light stimulation. Three distinct types of responses were recorded. (Figure 11.) The A-type (about 20%) respond with an initial burst of high frequency, a brief silent period followed by a steady low fre-

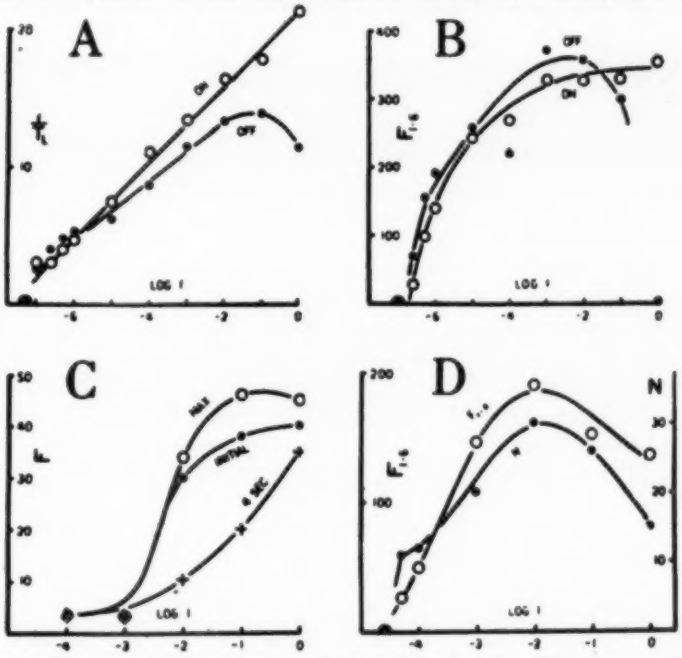

Fig. 11. Reactions of different types of single optic nerve fibre of the frog to changes in the intensity of the stimulus. A. Relation between the reciprocal of the latent period in secs. and the log-intensity of the stimulus in an on-off-fibre. B. Relation between frequency per sec. of first 6 impulses and log-intensity in same fibre. C. Relation between log-intensity and impulse frequency per sec. for different parts of the response of an on-fibre. *Dots:* initial frequency. *Circles:* Maximum frequency (3 impulses). *Crosses:* frequency after 4 secs. stimulation. D. Relation between log-intensity and frequency per sec. of first 6 impulses (Fl-6) (circles) and total number (N) of impulses (dots) of pure off-fibre. (Hartline, 1938, *Amer. J. Physiol.*, 121.)

quency discharge as long as the stimulation continues. The B-type (about 50%) respond with a short burst of impulses at high frequency when the light is turned on then stops responding until the light is turned off whereupon there is another brief burst of impulses. The C-type (about 30%) do not respond at all either at the beginning or during the stimulation but give a burst of impulses when the light is turned off. The discharge of the C-type usually takes some time to subside. According to this investigator, the fibers of the optic nerve of the frog fall into one of these three subdivisions although there may be some intermediate forms.* (Figure 12.) In general, however, the

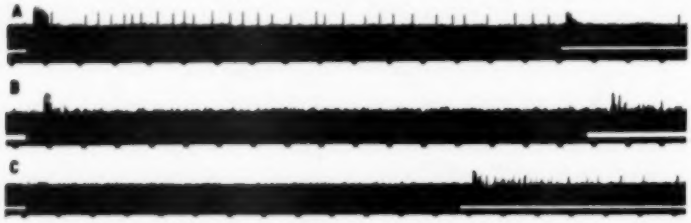

Fig. 12. Oscillograph records of the action potentials in three individual nerve fibers of the frog's eye, showing three characteristic response types. Time marker = 1/5 second. After Hartline, 1938.

higher the intensity, the shorter the latent period, the higher the frequency of discharge and the greater the number of impulses in a burst. High intensities, however, tend to inhibit the C-type response.

It can be seen from these results that most of the fibers (80%) of the frog optic nerve are inactive during steady stimulation. When the light is turned on 70% respond and when the light is turned off 80% of the fibers fire. It is clear that the response mechanism is so designed as to signal *changes* in illumination rather than steady stimu-

*Recently Kuffler (1953) has published an extensive paper summarizing the results of his studies of the discharge patterns of single ganglion cells from the unopened cat's eye. He found, among other things, that the discharge pattern of individual ganglion cells is not fixed. "On", "off" or "on-off" responses could be obtained from the same cell if specific zones within its receptive field are stimulated by small spots of light. The pattern, according to Kuffler, depends on such factors as background illumination, state of adaptation, intensity and duration of stimulus and extent and location of the area within the receptive field which is activated. Each of these variables was found to alter (by itself or in conjunction with others) the nature of the response pattern. Further it was found that there may be interaction between different regions within a single receptive field. Thus, under certain conditions, "off" areas may suppress the discharge from "on" and vice versa. It will be most interesting to follow these new developments since, as Kuffler points out, the discharge carried by the optic nerve fibers do, after all, contain *all* the information which the central nervous system receives from the retina. A correct interpretation of discharge patterns therefore constitutes an important step in the analysis and interpretation of visual phenomena.

lation. This means that whenever a change in illumination occurs, the higher visual centers are informed of this change by an additional burst of impulses. In this sense, the response mechanism may be considered an amplification device. (Figure 13.) These results have since

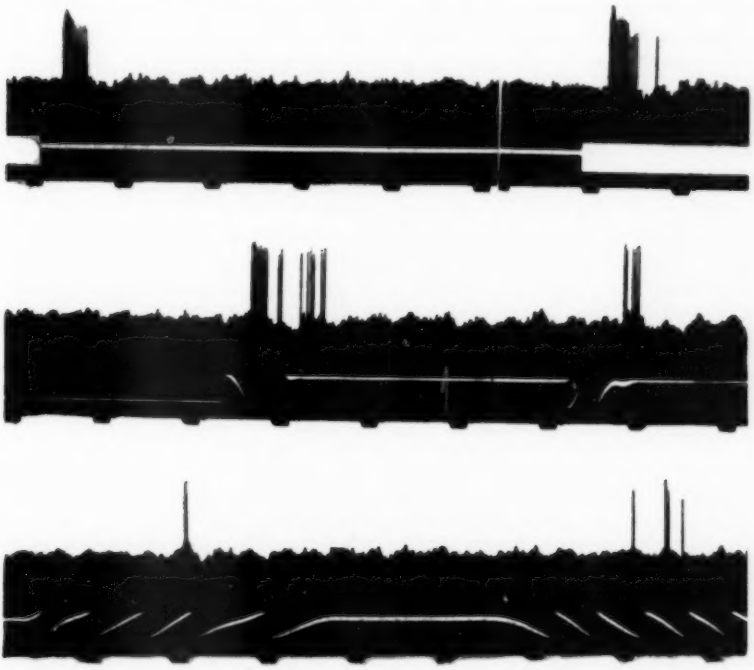

Fig. 13. Oscillograph records of action potentials in a single frog optic fiber showing responses to slight movements of a small spot of light (50 u diam.) on the retina. Movements are signalled by white line above time marker. Time = 1/5 second. After Hartline, 1940.

been confirmed by other investigators and their implications discussed (Granit, 1933; Bartley, 1939). Hartline (1938) himself found similar results in the eyes of the scallop Pecten Irradians.

The three modes of fiber response may be due to one of three causes: (1) they are produced by three essentially different types of sense cells. (2) the retinal layers between the sense cell and the ganglion cell layer produce them or (3) they are due to functional differences between ganglion cells. In view of the results obtained with the single element of the Limulus eye, all of which respond with the A-type dis-

charge, the second of the three suggested possibilities seems the most plausible.*

It must be emphasized that fibers which give a response to the onset and cessation of light also respond, though less strongly, to an increase or a decrease in intensity. Fibers giving only an off-response, will do so to a decrease in the light as well as its complete cessation. With dark adaptation, which has the same effect as an intensity increase, the frequency of discharge from any fiber increases. Off responses are weak or absent after short flashes and, as noted before, are inhibited by high intensities. Similarly, on-responses require a sufficiently long preceding dark period for their full development.† Finally, the discharges of the C-type is promptly suppressed by reillumination of the retina (see also Fry, 1934). The types of responses of A, B, and C groups seem to be relatively stable. They are supposedly not affected by asphyxia, Co_2, ion imbalance, temperature, adaptation or condition of stimulation.** Further the three types of responses have since been identified in the eyes of fish, amphibians and reptiles.

Granit (1947) P. 166-167, considers the significance of these results in terms of the duplicity theory. He writes:

> "Turning from the average retinal response to the results of the detailed analysis of impulse activity in separate fibers, it is clear that these *can* be interpreted on the basis of the duplicity theory so long as this is extended to include the synaptic organization of the rod and cone systems. From this point of view the results may be summarized in a general statement to the effect that *a cone system is a mechanism for differentiation, a rod system one for integration.* The properties of a rod system do not differ very much from those of an isolated receptor. The extensive convergence of a large number of receptors on to one final common path seems to be the main feature of the organization of a rod system and this is of obvious importance in the integration of the feeble stimuli characteristic of the scotopic eye. The cone system, on the other hand, seems to be organized for the interpretation of *changes* in the visual field, changes of illumination, of the area stimulated, of 'locus' in the field as a whole and, as we shall see, of colour."

Granit and Svaetichin (1939) have introduced a method known as the microelectrode technique which has provided an important supplement to the micro-dissection technique already discussed. This technique was originally developed as a rapid method for determining the color sensitivity of single or small groups of retinal elements and was chiefly used for this purpose. (Granit, 1947.) Hollow glass tubes are drawn out by means of a special heating and stretching apparatus

*See also the report of Motokawa and Ebe (1951).

†It should be pointed out, however, that Wilska and Hartline (1941) later found off-responses of the usual type from the optic lobe of the opposite side of Limulus. That is, only after the impulses have been passed through the ganglion do they become differentiated into the characteristic types. The more recent work of Kuffler (1953) should also be consulted in this connection.

**See Kuffler (1953).

until their tips are only a few microns in diameter—approximately the same size as the individual neurons of the retina and nervous system. These extremely small glass filaments are filled with fine silver wire or physiological saline solution to make a conducting electrode. The electrode is mounted in a special holder (micromanipulator) which is applied to the retina by removing the cornea, lens and vitreous and is inserted into the ganglion cell layer. This means that the electric current which is recorded is the result of the interaction of photoreceptors, bipolars and horizontal type cells. It is usually possible to pick up the activity of a single unit since by micromanipulation the electrode is placed nearer to one unit than to another. The electrical activity is amplified and presented to an oscilliscope and loudspeaker. The "nerve messages" thus become audible as well as visible. The technique has the advantage in that it can be used on warm-blooded as well as cold-blooded eyes. The electrodes do not pick up impulses from the optic disc or from the nerve outside the bulb. The reason for this is that in these locations the nerve fibers are insulated by epineural tissue which does not permit the charge to leak out on the electrode.

When the microelectrode technique is applied to the eye of the cat (and other mammals) it exhibits considerably more "spontaneous" activity than Hartline had found in the frog. The whole retina is hardly ever completely inactive although spots may react to a stimulus only on its removal. It is quite common to find an accelleration of the spontaneous discharge at "on" and "off." Since an increase of spontaneous activity in the frog is associated with dark adaptation and all the mammalian eyes described so far are dominated by rods, this prop- not the case because it is also found in pure cone eyes. The pressure of the electrode might be partially responsible. The spontaneous impulses may, generally speaking, be divided into two distinct types, those which are activated by illumination and those which carry on independently of any stimulus. The significance of this spontaneous activity is not clear. Granit regards a mechanism of this type as a useful means of balancing the adaptive fatigue to be expected in an organ like the eye which is used for continuous activity.

In 1940, Bartley and Bishop recorded the optic nerve discharge of the rabbit in situ. The optic nerve was made available for the insertion of fine needle electrodes by removing most of the skull and cutting away the anterior part of the brain. The discharge was fed into a vacuum tube amplifier which in turn activated a cathode ray oscillograph. The results indicate that the optic nerve response is a complex series of oscillations, one group instituted by the onset of the

flash and the other by its cessation. The on-response is of a duplex nature. For strong light the two large waves are fused into a large potential with two sharp peaks, the latencies of which vary only slightly with flash intensity till near extinction. (Figure 14.) When

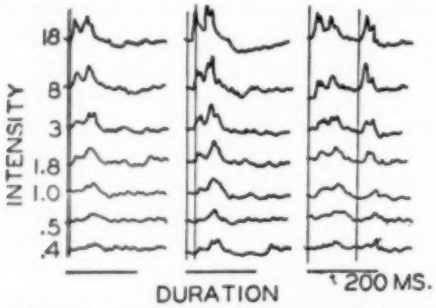

Fig. 14. A group of records of optic-nerve discharge. Both duration and intensity of flash were varied. Each column shows a series of responses in which intensity is decreased in each succeeding response. The numbers in the ordinate represent intensity in thousands of candles per sq. ft. Beginning at the left, flash duration is increased in each column. In the first, it is 8 ms.; in the second, 30 ms.; in the third, it is 135 ms. Note the clear separation between the major waves of the on-response and off-response in the third column. After Bartley, 1941.

the intensity of the light is near the threshold, the second of the two deflections emerges first and remains the larger of the two until the light is fairly bright. By the time the light has reached moderate intensities, the shape of the descending half of the first wave exhibits several evenly spaced and uniform sized ripples. The second half of the first response is generally smoother (Bartley, 1941). Its maximum appears about 30 msec. after the first and its amplitude falls as the intensity is further increased. The off response first appears with flashes of short durations but separates more clearly from the on-response if the flash lasts somewhat longer. It also consists of a group of oscillations of which the first is the tallest. The off-response as a whole approximates the on-response. The latent period of the on-response within the range of intensities tested varied from 15 to 65 msec. For the off-response, the latent period varied from 20 to 50 msec. By using a wedge-shaped opening in their episcotister, Bartley and Bishop were able to determine the characteristics of the response to a flash of gradual onset. They find that the optic nerve response reflects more nearly the effects of stimulation than the electroretinogram and conclude that the former is a more definite method of studying retinal function (Bartley, 1941).* See also comparison of electroretinogram and optic nerve

†See foootnote, end of Part II, following page.

discharge below.

It is admittedly difficult to evaluate these results on the basis of present knowledge. They are similar to the optic nerve discharge of the frog (Bishop, 1935) and peripheral nerves (Bishop and Heinbecker, 1933). In the end, any interpretation of these results which claims to be adequate, must take into consideration the electrical changes occurring in the retina which precedes the optic nerve discharge. It is tempting to envision the optic nerve discharge as an algebraic sum of the response types found in single nerve fibers by Hartline (1938). It would be further desirable to relate this to the electroretinogram and to trace the changes in electrical potential directly into nerve response. Such a program is, however, still in a preliminary stage. Granit (1947) has already presented considerable evidence, in his summary, that such a program is feasible; has indeed contributed much to make it possible. It is therefore necessary, before proceeding further, to consider the electric potential changes which originate in the retina itself as they are revealed by the electroretinogram.†

*More recent studies of the electrical responses of the visual pathway and particularly their selective reaction to anoxia have been reported by Noell and Chinn, 1950.
†Part III, The Electroretinogram, will appear in the November issue.

ABSTRACT

THE VALUE OF CLINICAL DATA. Marion Rush Stoll. North Carolina Optometrist. 16.5.5-6.1953.

The author points out that optometry is now producing, in its schools and colleges, reports of research studies which are of real value. Here data are studied by means of statistical analysis, carried out in accordance with the newer methods. These assist in eliminating false conclusions, which are easily reached when chance selection of inadequate material is used as the basis for the study. The author suggests that readers look for the words "not significant," "significant," and "highly significant," as these, when used, indicate that the newer statistical treatment has been applied by the research worker in reviewing his data.

CAREL C. KOCH

THE CORRECTION OF UNILATERAL APHAKIA WITH CORNEAL CONTACT LENSES*

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REVIEW OF THE LITERATURE

A review of the literature reveals that as early as 1914, the German ophthalmologist Erggelet first suggested using contact lenses for the correction of aphakia, but a survey of current practice indicates that this type of therapy has by no means reached its fullest potential. Erggelet proposed also the possibility of restoring fusion and stereopsis by such a fitting.

It is interesting to note that the literature contains several rare cases wherein binocular vision has been attained using a spectacle lens over the aphakic eye. In a paper presented before the Canadian Medical Association in 1932, Drs. Conrad Berens and Paul Connolly[2] reported that they had been able to achieve single binocular vision in several young patients by giving the strongest lens possible to the phakic eye and undercorrecting the aphakic eye. Observing a tendency on the part of young patients to suppress vision in the aphakic eye and develop an exotropia, Berens and Connolly emphasized the importance of prescribing lenses following cataract surgery. The ophthalmologist, Dr. Alfred Cowan, was quoted by them as saying that "in unilateral aphakia single binocular vision is not to be considered." They were able to report to the contrary two cases where satisfying results had been achieved with young patients.

The first case involved a male patient, age 24, corrected with:

O.D. + 0.50 D. sph. V.A. = 20/20.
O.S. +11.00 D. sph. V.A. = 20/20, with +3.75 add.

A program of intensive orthoptics was followed, and the patient was reported as being "comfortable and apparently fusing at all times."

A second case involved a male, age 20, whose correction was:

O.D. — 0.75 D. sph. V.A. = 20/15.
O.S. +11.00 D. sph. $\bigcirc$ —2.00 D. cyl. axis 75. V.A. = 20/70 with +7.50 add.

Orthoptics followed the correction and "with great difficulty patient was

*Read before the Illinois Chapter, American Academy of Optometry, Chicago, Illinois, February 1, 1953. For publication in the October, 1953, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
†Optometrist. Member of faculty. Fellow, American Academy of Optometry.

able to fuse certain stereoscopic charts by partially correcting a 6 prism diopter hyperphoria." Later a full correction was given for the muscle .mbalance, and "patient fused well when reading."

From time to time, cases are reported in ophthalmic literature of aphakic patients wherein the eye apparently accommodates for near objects. In 1931, Koch[3] reported a patient who required the following distance correction:

O.D. + 8.50 D. sph. V.A. = 20/25.
O.S. +11.00 D. sph. ⊃ —2.00 D. cyl. axis 120.
V.A. 20/40

With this distance correction the patient could achieve normal nearpoint visual acuity to 11¼-inch nearpoint distance, and was completely satisfied with this correction for both far and near.

Somewhat more frequently reported are case studies of the successful correction of monocular aphakia with a contact lens. In 1933, Foster and Jackson[4] reported several cases of successful correction with a monocular contact lens that resulted in satisfactory fusion and binocularity. In 1943, Greenspoon[5] presented a case of successful correction of unilateral aphakia and hyperphoria with a contact lens. After several contact lens trials, he determined that a lens with as flat a corneal curve as possible and with sufficient vertical prism to eliminate vertical imbalance was required. A +12.00 D. contact lens with a 3½ △ prism base-up was used. The initial diplopia experienced was eliminated during the first week of wear. "With the aid of the lens, the patient was qualified for a position that required binocular vision." Using a monocular corneal lens, Graham[6] recently reported a correction in which the combined use of a corneal lens and spectacle lens in trifocal form resulted in good fusion and binocularity with unlimited wearing time.

In most of the case studies just discussed, one is impressed by the omission of certain important data which would permit a more critical evaluation of the problem: (1) Every practitioner, except Graham, failed to report the length of clear, comfortable wearing time of the contact lens. (2) There was no statement of: (a) The status of the patient's fusional amplitudes, phoric tendencies, and accommodative facility as determined by refractive analysis. (b) The level of binocular fusion and stereopsis as measured by accessory test procedures. (c) Any individual measurements of the induced aniseikonia.

TWO PERSONAL CASE REPORTS

The author has selected from his own practice two cases, each presenting a somewhat different problem . . . each requiring specific

therapy to meet the demands and needs of the patient. In both cases, every area of visual functioning was investigated as thoroughly as possible.

Case 1. Mr. P. H., age 52, suffered a severe blow to the left side of the face resulting in a traumatic cataract which was surgically removed in late 1950. The patient reported that due to loss of vision in his left eye, automobile driving seemed a hazardous undertaking and, as a result of this loss of confidence, he eventually avoided this activity almost completely. Equally disturbing to him was his mounting golf score, formerly in the high 70's, now in the high 90's and low hundreds, which he attributed to inability to keep his head down and still follow the ball in flight. Through a +17.50 D. corneal lens, an acuity of 20/20 was achieved in the aphakic eye equaling the unaided acuity of the normal eye. Adjusting to the added weight of this correction required several alterations of the lens diameter to the tenth of a millimeter. This, in turn, overcame the tendency of the corneal lens to sag excessively. Within two months, the patient enjoyed unlimited wearing time. When he was examined for a change in his habitual reading prescription, his performance was most unexpected. He reported complete comfort at nearpoint through a low plus spherical reading correction which he had worn for reading prior to the traumatic accident. This facility was dramatically confirmed by the fact that his monocular ranges were within 1 inch of each other on .62m Jaeger type, the normal eye blurring at 11 inches, the aphakic eye at 12 inches.

The Visual Skills battery again revealed some interesting findings:

Far: First degree fusion—passed
Second degree fusion—passed
Stereopsis—44%
Visual acuities—OD and OS equal and passed
Vertical and lateral phorias—passed

Near: Second degree fusion—passed
Stereopsis—16%
Visual acuities—OD and OS equal and within 1 circle of passing
Vertical and lateral phorias—passed

On the Airplane DC series, a very critical measure of depth perception, macular stereopsis was established at the 5% level.

Results of the graduated 4-ball Progress of Fusion series was 100%. It should be noted that this test is not so much a measure of critical fusion as it is an indication of ability to superimpose a bi-dimensional target and resist diplopia.

Measurement on the AO clinical Space Eikonometer indicated an overall induced aniseikonia of 9½% with an accurate range of sensitivity ±0.50%.

The refractive analysis revealed a high level of fusion and binocularity:

Habitual lateral phoria—distance		1 exo	
Habitual lateral phoria—near		4 exo	
Static retinoscopy	O.D.	+0.50 sphere	
	O.S.	+0.25 sphere	
Dynamic retinoscopy at 20″	O.D.	+2.25 sphere	
	O.S.	+1.75 sphere	
Subjective	O.D.	+0.25	20/15
	O.S.	Plano	20/20
Induced lateral phoria through subjective (distance)		Ortho	
True adduction		10	
Convergence		20/2	
Abduction		10/6	
Vertical phoria—distance		1 rt hyperphoria	
Induced lateral phoria through subjective (near)		8 exo	
Unfused cross cylinder	O.D.	+2.50	
	O.S.	+2.50	
Induced phoria through unfused cross cylinder		11 exo	
Fused cross cylinder	O.D.	+2.50	
	O.S.	+2.50	(control)
Induced phoria through fused cross cylinder		10 exo	
Positive relative convergence (16″)		19	
Positive fusional reserve		21/6	
Negative relative convergence		20	
Negative fusional reserve		28/18	
Vertical phoria—near		Ortho	
Amplitude of accommodation (13″)	O.D. 2.75	O.S. 2.75	O.U. 2.50
Positive relative accommodation	—1.25		
Negative relative accommodation	+0.75		

All of the tests indicate a well stabilized binocular visual pattern with a measurable degree of stereopsis, greater at far than at near. The accommodative amplitude in the aphakic eye was indeed unusual. It is difficult to explain how this is physiologically possible, for it seems to take exception to the concept of the function of accommodation as residing solely in the action of the crystalline lens.

Mason[8] offers an explanation for this apparent accommodation on the basis of "a caustic surface in the refracted rays which focus near the retina, ascribing to the eye the ability to select varying regions upon the caustic for the creation of the image by which a near object is perceived." He states further that "although knowledge is scarce respecting the causation of this phenomena it is, nevertheless, a representation of a feature of the eye's performance which is commonly observed upon the intact eye, namely, the ability of the eye to discriminate small detail at the reading position while, in fact, being focused for vastly greater distances."

Case 2. Mrs. F. H., age 42, underwent surgery for the removal of a traumatic cataract of the right eye in 1940. From that time, the patient had noted an occasional exotropia of the aphakic eye which at first was present only when she was very tired; in time this condition occurred

more frequently. A corneal lens fitting was begun in 1950. Through a +17.00 D. corneal lens 20/25 acuity was achieved, compared to a 20/20 unaided in the normal eye. Due to some pigment loss in the iris of the aphakic eye as a result of the surgery, the corneal lens was tinted a light green, thereby matching the iris pigment of the normal eye.

Unaided nearpoint ranges on .62M Jaeger type:

O.D. in to 14 inches

O.S. in to 8 inches

Unaided acuity at near (16 inches):

O.D. 20/40

O.S. 20/20

External ocular examination revealed the pupil of the aphakic eye to be round, 2 mm. smaller in diameter than the normal eye, and more sluggish in its reaction to light.

The Visual Skills in this case were successfully achieved in many areas:

Far: First degree fusion—passed
Second degree fusion—passed
Stereopsis—fused target but no depth seen—0%
Visual acuities—O.D. failed
O.S. passed
Vertical and lateral phorias—passed
AN 5 card showed good depth of the mountain scene with fusion of all numbers

Near: Second degree fusion—passed
Stereopsis—fused target with depth—0%
Visual acuities—O.D. failed (identified first two circles only)
O.S. passed
Vertical and lateral phorias—passed

Progress of Fusion Series (4 balls): 40%.

Measurement of the AO Space Eikonometer: Overall induced aniseikonia of 10.5%, sensitivity of ±1.00%.

Refractive analysis findings:

Habitual lateral phoria—distance	Ortho		
Habitual lateral phoria—near	3 exo		
Static retinoscopy	O.D.	+0.75 sphere	
	O.S.	+0.25 sphere	
Subjective	O.D.	+0.50 sphere	20/20
	O.S.	+0.25 sphere	20/20
Induced lateral phoria through subjective (distance)	1 eso		
True adduction	X		
Convergence	4/2		
Abduction	3/0		
Vertical phoria—distance	Ortho		
Induced lateral phoria through subjective (near)	2 exo		
Unfused cross cylinder	O.D.	+0.75 sphere	
	O.S.	+0.50 sphere	
Induced phoria through unfused cross cylinder	6 exo		

Fused cross cylinder	O.D.	+1.50
	O.S.	+1.25
Induced phoria through fused cross cylinder		10 exo
Positive relative convergence (16″)		X
Positive fusional reserve		4/1
Negative relative convergence		X
Negative fusional reserve		16/12
Vertical phoria—near		Ortho
Amplitude of accommodation (13″)	O.D.	2.00
	O.S.	4.50
	O.U.	4.25
Positive relative accommodation		—1.75
Negative relative accommodation		+0.75

Visual findings on this case, like those of the preceding one, show a binocular pattern existing with low fusional amplitudes and a measurable degree of accommodative amplitude present in the aphakic eye. The patient now enjoys unlimited wearing time and is able to read for short periods of time with comfort. In the past she preferred to remove the lens and read monocularly. Recently a slight exotropia was noted when she did not wear the lens, and she now prefers to wear it constantly. At the present time she is being fitted with a combination of contact lens and spectacle lens on the normal eye which will virtually eliminate the induced aniseikonia. A —3.50 D. corneal lens on the normal eye combined with a +3.50 Diopter spectacle lens at the APF together with a balancing plano spectacle lens before the aphakic eye has reduced the aniseikonic error to within 1%. Boeder[7] has shown by mathematical computation that such a telescopic system of lenses would produce equality of the ocular images; i.e., that an emmetropic eye made 3 diopters hyperopic by a contact lens, then corrected for this induced error by a spectacle lens together with a plano spectacle lens before the aphakic eye would eliminate the average 11.4% image disparity which formerly had existed. In trial frame form, patient has reported complete comfort and shows nearly balanced monocular ranges.

SUMMARY AND CONCLUSIONS

To date, the author has had the opportunity of correcting 8 unilateral and 1 bilateral aphakic patients. All but one have been corrected with corneal lenses, and only one patient of this group does not enjoy unlimited wearing time.* Because of the presence of corneal scars which have reduced the visual acuity of the aphakic eyes, binocularity has not been achieved in all cases. Experience seems to indicate that contact lenses are particularly well suited to aphakics. Their rapid adaptation to the lens might be accounted for in part by an apparent "desensitization" of the cornea following cataract surgery. Since the

*The Tuohy corneal lens was used for these cases.

contact lens lies very close to the site from which the crystalline lens was removed, this is optically the preferred way to restore the lost power. There is no limitation to the visual field as there is with spectacle lenses.

In addition to these advantages, fusion is more easily maintained with a contact lens than with spectacle lenses. With the latter, when there is a difference of 10 or more diopters, the prismatic imbalance is 1 prism diopter for each millimeter that the eyes turn from the optical center of the lens. At 3 mm. from the center, diplopia can exist for this reason alone. This is obviated by the use of a single contact lens or a pair of contact lenses, since the aphakic eye obtains its vision through the optical center of the contact lens at all times, regardless of the rotation of the eye. Peripheral and prismatic distortions are thereby eliminated; moreover, there is no appreciable alteration of the wearer's appearance. Any residual aniseikonia can usually be corrected by adjusting the components in the correction and balancing with spectacle lenses.

The problems of visual rehabilitation following cataract surgery are indeed challenging. A fuller realization of the inherent value to the unilateral and bilateral aphakic patient of this type of therapy is highly desirable. This is but another evidence of the many services the professional optometrist may render to enhance the efficiency of human vision.

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MILESTONES IN OPTOMETRIC HISTORY

It is interesting to review some of the significant forces which were set to work at various periods in the development of optometry. Forces which had so marked an effect on the future of the profession. By so doing one can trace the development of optometry from its beginnings in the 17th century optical instrument makers guilds of Europe. During this 350 year period much of interest has happened.

As guild members, in the field of instrument making, with spectacles as a more or less incidental activity, these early workers gradually changed the emphasis of their interests until the making of spectacles became their major occupation.

Naturally, at first these glasses were sold as a commodity. The

frames were glazed with either convex or concave spherical lenses of equal power. There were no refractions done in those days. The user selected the spectacles as best he could. At first, supplying only the materials—then, little by little, as knowledge of these matters increased—improving, first the quality of the materials—then improving the service by adding tests for visual acuity at far and near, and later adding other refractive tests dealing with binocular vision and astigmatism. Later still, examination procedures were added, and additional refractive refinements dealing with the eye and their proper functioning were developed and brought into wide use. Several centuries slid by while these changes took place.

At one stage in the growth of the profession optometry might have become a calling more or less similar to pharmacy. Optometrists, in fact, did live and practice through that stage, but because of the excellent leadership provided by Charles Prentice, Andrew J. Cross and their colleagues it did not stop there. To be sure, many of the optometrists of that day (1890) were content only in serving others and in doing simple routine tasks. But men like Prentice, Cross and later Albert Myer, had broader vision. These men realized the need for a complete refractive service and the science underlying it, and they kept on raising the ideals and the standards of practice so that the trend lay away from the supplying of materials towards the true goal of a well rounded professional service in which the materials played only a part. This marked one of the significant turning points of the profession.

At a somewhat later time (1912) another milestone was passed. Optometry was then rapidly developing professional stature and its real service to the public was becoming more and more evident. At this point medicine decided to take optometry under its wing and make an ancillary group of it. The technique of doing this was the same which they later followed successfully with the physio-therapists, radiographers, speech therapists, dietitians, biophysical assistants, laboratory technicians, those who administer massotherapeutics, as well as other groups now somewhat or entirely subservient to medicine.

But this was not to be. Optometry was again fortunate in its leadership. Albert Fitch and his colleagues in Philadelphia were able to turn back that move and in so doing laid the groundwork for an independent, yet cooperative, optometry with full professional status of its own.

And, a few years later (1922) a third significant meeting took place at St. Louis, where a group of optometric educators, under the leadership of Howard C. Doane and William S. Todd met to take the

steps necessary to eliminate the remaining proprietary schools from the scene and to lay, for all time, the foundations for the non-profit optometric schools and colleges which serve us so well at the present time. This meeting, too, was a significant milestone in optometric history.

From then on the evolutionary development continued with statutory recognition everywhere, with improved educational standards resulting in better examination and refractive work and with higher standards of practice becoming more evident. With these developments came the confidence and security which goes with competent professional leadership.

But to return to the speculations brought about by this brief review. What would have happened to optometry if, some 60 years ago, a small group of determined men had not met in New York City and decided from the optometric viewpoint, there was more to be done in the public's interest than to continue to practice in the establishments of that day with only their simple subjective refractions? When this decision was made, first by Prentice and later on by Cross and Myer and their A.O.A. workers—these positive principles and the effort put into getting them widely adopted, marked an optometric turning point of great magnitude. Without their courage and foresight, present day optometry might not have come into being.

And later, when the proposal to become medical auxiliaries was made, the future of optometry once more hung in the balance. But here again, a small alert group led by Albert Fitch made the important decision to keep optometry independent. These men claimed, and the courts later upheld them, that refracting was not a part of the practice of medicine and that optometry should continue to have independent status. This decision had its immediate effect upon the profession as it stimulated its development and through the years has made optometry self sufficient and reliant. In addition, it has provided all persons with a large reservoir of *optometrists* whose major interest is *refracting*. Thus today, this decision enables us as a professional group to properly serve a great segment of the public to their complete satisfaction, and it will also affect Americans in the years to come as independent optometry will go on serving in the future as it has in the past. It was another great milestone in the history of optometry.

And when the last of the proprietary schools was eliminated from the scene the real opportunity for educational advancement was opened. As the interests of the profession became paramount, better training in the basic sciences became possible. In addition better clinical facilities were made available for the students who were given an opportunity

to become well educated in optometry in the public's best interest. Again a milestone of lasting moment was passed with flying colors.

These and other great moments in the development of the profession are of particular significance to us today as they indicate the splendid heritage of optometry and the underlying strength of our profession. A strength gained in part in the days gone by—and they signify, too, the fine possibilities we may look forward to in the future.

CAREL C. KOCH

FOUNDATION MEMBERSHIP DRIVE NOW UNDERWAY*

In every generation the professions are given the opportunity to render some outstanding service; to humanity, to their associates, and to themselves. When they rise to the occasion, significant progress is made—when they fail, the profession fails to advance, and individual members are denied opportunities to which they are entitled.

The profession of optometry is no exception to this rule. Optometry made a most spectacular growth during the early years when it was necessary to fight for its very existence. With the enactment of laws by every State regulating the practice for the protection of the public, a feeling of complacency seemed to settle over many optometrists which made is necessary for those placed in positions of responsibility in State and national organizations to alert the profession from time to time as new possibilities for service presented themselves. The membership of these organizations expect their leaders to keep them informed of opportunities or emergencies, and unless optometrists are alerted from time to time the profession of optometry will reach a given level and then begin to decline.

There are many opportunities in optometry today, but in the opinion of many, the American Optometric Foundation is one of the most important. Before outlining some of the objectives of the Foundation, and what it is already doing, it should be stated that without exception every organization in optometry approves of the Foundation, and believes that it is essential to the preservation and perpetuation of optometry to have a well organized and financially strong Foundation. All of the Foundation objectives are important. In order to put them into operation, a substantial Permanent Fund, and a large annual income, are necessary.

It will be recalled that the American Optometric Association caused

*By William C. Ezell, Optometrist. President, American Optometric Foundation. Past President, American Optometric Association. Fellow, American Academy of Optometry.

the Foundation to be organized and chartered, and the A. O. A. is a Life Member. The present President of the A. O. A., and six of the Past Presidents, are paid-up Life Members, and five are Active Members as well. The Academy has endorsed the Foundation and the President and Secretary are members, as well as many other Academy members. The Association of Schools and Colleges has endorsed the Foundation and the President of the Association is a member.

Many of the Optometry schools and fraternities are Life Members. The A. O. A. Woman's Auxiliary has adopted the Foundation as a major activity and is working toward a third Life Membership. Many of the state and some of the local Auxiliaries are Life Members, and two of the State Auxiliaries are now raising money for a second Life Membership.

In organizing the Foundation, the Directors established what is known as the Advisory Research Council. The personnel of the Council is composed of a representative of each of the optometry schools and colleges and certain scientists connected with ophthalmic optics. While it is the responsibility of the Foundation Board of Directors to make the final decision on research and other activity, all projects are first screened through the Council.

The Foundation has five current grants to Research Fellows, and grants were previously made to three others. A study of "Visual Problems in Viewing the Television Screen," was financed and completed at the Los Angeles College of Optometry.

At the joint meeting of the Foundation Directors and the Advisory Research Council several additional projects were discussed. One of these was the writing of optometric textbooks, and a committee was authorized to be appointed to make suitable recommendations for this phase of Foundation activity.

Another of the projects that the Foundation has been asked to help finance is the compilation of a modern and comprehensive self-pronouncing "Dictionary of Visual Science." Applications are also frequently received from optometrists seeking the assistance of the Foundation in the completion of their post-graduate training, who expect to make teaching in an optometry school their careers; others come from young people who wish to study optometry but who need financial assistance. Still other requests are received from those who wish to establish themselves in practice. The Foundation has on file a long list of research projects that need to be done. The only thing that keeps these applications from being voted on favorably is the lack of funds, and this *need not be the case* if optometrists in large numbers will become

members.

The Permanent Endowment fund of the Foundation now exceeds the $100,000 mark, and is all invested in U. S. Government Bonds. There are 883 Active Members.

All Academy members and readers of this publication are urged to become members at this time. An organized membership campaign is now getting underway during which all optometrists will be invited to join. *Many* can easily become Life Members upon the payment of $500 in cash or installments according to plans that have been worked out. *All* can well afford to become Active Members. Active Membership is $15 a year. Now is the time to invest in the Foundation which, in reality, is investing in your own future, and the future of our profession. Membership and contributions to the Foundation are deductible from income tax. Put some of your surplus money into a fund that is dedicated solely to the advancement of visual care and the promotion of optometry.

Everyone has endorsed the Foundation but lip service is not enough: your active participation as a member is essential. The members of the Academy and the readers of this publication are the leaders in education, and in ethical practice, and many hold positions of responsibility in optometric organizations, State and national. This means that this group has more responsibility in the promotion of worthwhile undertakings, like the Foundation. The Foundation greatly needs the assistance of this body of optometrists in promoting the Foundation and securing members. The Academy, and all subscribers to its Journal, are urged to adopt the Foundation as a major professional activity. In doing this, Optometry and the Academy will make the words of Henry David Thoreau come true as he says: "I hear beyond the range of sound; I see beyond the range of sight."

WILLIAM C. EZELL

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SPECIAL REPORT

CAUSAL AND SYNDROMATIC ANALYSIS*

William F. Garber†
Minneapolis, Minnesota

One of the most familiar ways of explaining occurrences is in Cause and Effect terms: that is, a specified cause is related to a given effect. To reduce this relationship to *unequivocal* terms is the goal of scientific method, probably never to be perfectly attained. Especially as it relates to human behavior, as Brunswick[1] emphasizes, a cause is *equipotentially* related to its effects: *i.e.*, a number of possible effects may follow. It is for this reason that we need optometrists, not merely machines, to evaluate vision. If completely predictable results would always follow quantitatively and qualitatively varied stimuli, this would not be the case.

What saves the situation is that the gross shapes of events tend to repeat themselves in a predictable linkage, even with changes in structural content. An apple dropped from a height falls downward, whether the event occurs at the Pole or the Equator. It is this potentiality we have of seeing events in outline that makes scientific prediction possible. "Scientifically, situations can only be treated as abstractions, never in terms of their inexhaustible, concrete reality."[2] The author is referring here primarily to social situations, but as Gurwitsch[3] notes, the same principle holds for events involving inanimate objects. "If we go beyond the perceptual level, account must be taken also of the idealizing processes through which the causal properties receive mathematical formulation and find expression in the concepts of physics like mass, conductivity of heat, index of refraction, electrical conductance." Thus scientifically the goal in explanation remains the causal analysis.

Often preceding and later accompanying the causal analysis, we may find the following approach: E_1, E_2, E_3 ... $E_x = E'$. That is, given a limited constellation of effects, we may presume that a molar effect is occurring. This is the familiar syndromatic approach of medicine. From a certain temperature, blood pressure, blood count and various other symptoms, a physician concludes that a particular disease process is in progress.

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Note that this method says: Given a series of results, we may predict another major result. It is thus not to be confused with inductive thinking, which leads from results to the cause. Syndromatic analysis is classificatory rather than causal. To conclude that someone is a myope is not to explain his condition. It is, however, true that under certain circumstances elements of causality may enter into the syndromatic explanation.

While crudely, this approach enumerates symptoms, a more refined level is reached when a time and spatial pattern is sought for these symptoms. This is what the Optometric Extension Program tries to do when it looks for syndromatic chains in terms of a theory of progressive deterioration. From the standpoint of a psychologist as well as an optometrist the weakness I find here is that the interrelationship of factors rises not so much from the proven dynamics of the situation as from the theory which has been "tailored" to fit the factors, and which is largely a theoretical superimposition rather than a theoretical deduction. This is essentially what Dobb means when he writes: "As long as mathematical technique retains its servitude to a particular mode of thought, the concepts which it fashions are calculated to veil rather than to reveal reality."[4]

Furthermore, while as in OEP theory, some recognition is given to the time factor, a major defect of the syndromatic approach is that it fails to encompass adequately historical relationships. This is true in at least two senses. In relationship to each other, events occur in a time frame, and the enumeration of symptoms often subordinates this complexity or crudely may classify it as "stages" of the disease (again a classificatory rather than causal approach). Secondly, variations from norm are given inadequate consideration as functions of personal history. To take an obvious example, a "fat" person may actually be seriously underweight in terms of his own personal history, he may be merely of normal weight when that history is considered as the norm, or he may be seriously overweight. Tables of "expecteds" in optometry to a degree illustrate this defect of syndromatic analysis. The best basis for urging frequent visual reexaminations might well be not the emphasis on the static detection of change, but that only through knowledge of a patient's visual history can the optometrist adequately prescribe for his present day condition.

Of course, the syndromatic approach is often inevitable in the absence of knowledge that would allow more genuinely causal analysis. It serves its function best when it is recognized as only a stop-gap method, valuable as an indication of what procedures to select from

the melange at the practitioner's disposal, but decidedly weak in enhancing progress in understanding. The greatest misuse of this method occurs when the syndrome complex is expanded beyond any utilitarian standard—like a child aimlessly stacking blocks for the mere sake of activity. This occurs in optometry when a series of syndrome-formuli is provided for the recognition of claimed visual types, but the actual criteria for recognition of these types are only a few elements in the complex.

The fact is that visual research in *C—E* terms is currently too much the function of psychologists, medical men and physiologists. This is not to the credit of optometry. Those who would contest this statement need only be asked how many non-optometric texts in the field of visual research have found it necessary to mention the optometric contribution.

To an extent, this partial vacuum arises from a number of causes, many of which are being corrected. We are "fenced-in" frequently through prejudice. At least for research purposes and causal analysis, a greater freedom in procedure would be valuable to the optometric worker.

SUMMARY

Causal analysis seeks to relate an event to its cause and may be contrasted with *syndromatic analysis*, which merely relates a number of sub-events to a major event. While the perfect causal explanation is probably impossible due to the multiplicity of inter-related events, scientific causal explanation is made possible by concentrating on the main features or outlines of events. These remain relatively stable in spite of variations in content.*

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*The author wishes to thank Dr. John J. Sullivan, Professor of Psychology, New York University, for his clarification of some concepts discussed in this paper.

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CURRENT COMMENTS

Terry Judith Parkins
Editorial Assistant

Optometrists will confer a favor by sending news items of general interest for this department: such as relate to new instruments, clinical techniques, education, visual health and optometric legislation and organization.

ROBUST LEADERSHIP IN NEW YORK

In reading a recent issue of the JOURNAL OF THE NEW YORK STATE OPTOMETRIC ASSOCIATION I came across a series of resolutions adopted at the 58th annual convention of this group. These resolutions seemed to differ from most resolutions passed at such optometric meetings. The resolutions adopted in New York not only mentioned the problems under consideration, but also spelled out the techniques suggested by the association to correct the problems. The resolutions had punch and vigor. They indicated that the officers mean business.

Dr. Harold M. Fisher, New York City, is president of the association. He is also a past-president of the Academy. Knowing Dr. Fisher by reputation, I suspect that things will happen down east—things which will stimulate optometry, and go far in protecting the public.

One whole group of resolutions dealt with the problem of lay persons employing optometrists. They spelled out the dangers in this practice and presented suggested methods to be used in correcting them.

Another resolution dealt with the problem of orthoptic technicians practicing away from professional supervision. This resolution outlined the procedure wherein proper law enforcement officials of the State of New York could correct this abuse.

For years New York State has had a law, in the form of a health regulation, prohibiting the sale of ready made focus glasses. During the past several years certain commercial groups have unsuccessfully attempted to have this law repealed. The optometrists, through their association, will continue to support the regulation to their fullest ability, in the public's interest.

The New York State Optometric Association considers visual screening part of the practice of optometry and objects to this being done by lay persons. It has instructed its officials to collaborate with law enforcement people so that all visual screening tests may be accompanied by proper professional interpretation.

The association also objected to the more-or-less common practice, among certain manufacturers of ophthalmic materials, of selling these

materials to some retail dispensing opticians at factory-list prices. This is done, the association points out, on the pseudo-assumption or claim that the material is for re-sale to professional men. In reality, such a practice gives the retail dispensing optician who has this privilege an unfair economic advantage over the individual optometrist in practice, who enjoys no such preferential treatment, as the materials used by optometrists in their practices must come to them through the usual and proper laboratory channels.* Here the association calls for a thorough investigation of the matter and sets up the machinery to do this. It also calls upon the American Optometric Association to conduct a similar study on a country wide basis, to gather facts to be used in putting an end to this practice.

The New York State Optometric Association has recognized some of the major problems effecting optometrists and their livelihood and has brought them out in the open. Here these economic problems can be studied and corrected. Dr. Harold M. Fisher and his associates deserve the 100 per cent support of all New York State optometrists. They will unquestionably get this support, too, as this is the exact kind of leadership which builds a strong and united optometry.

WHY PICK ST. LOUIS AS AN A.O.A. HEADQUARTER CITY

The American Optometric Association has announced the establishment of a centralized headquarter office in St. Louis, Missouri. The administrative director of the association, Mr. J. Harold Bailey, will be in charge. The A. O. A. Department of Public Information has already been moved to St. Louis from Pittsburgh and in time, some of the functions of the association now handled by the secretary in Minneapolis will also be transferred to St. Louis.

The centralization of functions for the association is all to the good. This is a long awaited move on the part of the American Optometric Association and a needed one in the profession's interest. Other professions have long had functional headquarter offices and there has been a growing demand in optometry that something similar, of value, be done for us to unify the now scattered activities of the A. O. A.

For some time the obvious choices of Chicago, Washington, D. C., and New York City had been mentioned as possible headquarter cities. Chicago, because other professional groups already headquarter there and much needed contacts could more easily be made, and also because

*Editor's Note: Some few optometrists also enjoy this economic advantage. This, too, should be studied.

of its unsurpassed air-travel and railway advantages. It, too, is a mid-west central city. Washington, D. C., because much of the future of optometry will be decided there and our officers will spend more and more of their time in the Capitol city. A headquarter office, right on the spot where the decisions are made, would make these visits more fruitful. New York City, because it is a recognized public relations center and because of its eminence in the affairs of all of us in these United States.

St. Louis, unfortunately, lacks all of these advantages to us as a professional group. The choice of St. Louis is a disappointment. It is unquestionably a very pleasant place to live but that is not the point now under consideration by the profession. Few important contacts can be made in St. Louis by the staff and there is simply nothing in St. Louis to anchor the office there permanently.

The writer is pleased to see a centralized office for the A. O. A. open up and get underway. It is a necessary development. But it does seem that such an office could have been placed where the staff could make some useful connections in our behalf. St. Louis is not the place where this can be done, nor are decisions of importance to optometry frequently made there. If this is just a temporary move until the association is ready to locate in some important economic or political center, it is a step in the right direction—but if so, the press releases dealing with the new office do not indicate it.

TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

ANNUAL ACADEMY MEETING — DRAKE HOTEL

CHICAGO, ILLINOIS, DECEMBER 5 - 8, 1953

HOTEL RESERVATIONS

Academy members are urged to make their hotel reservations for the coming annual meeting of the American Academy of Optometry, Chicago, Illinois, December 5-8, 1953, at the Drake Hotel. Requests for room reservations should be sent directly to the Convention Department, Drake Hotel, Chicago, Illinois.

THE MEETING

The meeting will again be a four-day session devoted to the

presentation of original papers, supplemented by a special visit to the University of Chicago Reading Clinic on Tuesday afternoon for those members and guests interested in this special training work. This visit will take place during the regular program.

Some of the original papers which will appear on the program follow:

The Influence of Elevation, Depression and Convergence of the Lines of Sight on Cyclophoria. Merrill J. Allen, Ph.D., Division of Optometry, Indiana University.

The Effect of Luminance of the Contact Inducing Flashes on the Spatial Range of Metacontrast. Mathew Alpern, Ph.D., School of Optometry, Pacific University.

The Design of Magnifiers for Use in Cases of Subnormal Vision. Edwin W. Bechtold, B.S., M.A., School of Optometry, Columbia University.

The Frequency of Monocular Color Blindness. Israel Dvorine, O.D., Baltimore.

Amplitude of Cyclo-Fusional Movements. V. J. Ellerbrock, Ph. D., School of Optometry, The Ohio State University.

High Resolution Lenses for the Partially Blind, A Preliminary Report on 150 Cases. Eugene Freeman, Ph.D., Dean, Chicago College of Optometry.

Near Point Visual Tests for School and Industry. Glenn A. Fry, Ph.D., Director, School of Optometry, The Ohio State University.

Visual Dysfunctioning Originating from Neurotic Causes. Emmanuel Gobeil, O.D., Clinique de Rehabilitation Visuelle, Montmagny, Quebec.

Brightness Difference in Seeing. Sylvester K. Guth, D.O.S., General Electric Company, Nela Park, Ohio.

The Importance of the ACA Ratio in Industry and Schools. Fred W. Jobe, Ph.D., Director of Ophthalmic Research and Development, Bausch and Lomb Optical Company.

Optometric Correction of Strabismus. A New Approach. (With Colored Slides) John R. Kennedy, O.D., St. Paul.

Visual Investigations of Mentally Retarded Children. M. Kirschen, O.D., Modesta, California.

Accommodative Response of the Eye to Electrical Stimulation of the Ciliary Ganglion. Elwin Marg, Ph.D., School of Optometry, University of California.

Compensating Bifocals for Cases of Anisometropia. George A. Parkins, O.D., Ord, Nebraska.

The Changing Attitude to the Partially Sighted and the Blind. Joseph I. Pascal, O.D., M.D., Polyclinic Medical School, New York City.

The Relationship Between Aniseikonia and Achievement in Reading. Alfred A. Rosenbloom, O.D., Northern Illinois College of Optometry.

A Group Screening Test for Visual Acuity. C. F. Schumacher, M. S., and A. R. Lauer, Ph.D., Iowa State College.

Demonstration and Application of the Objective Determination of the Visual Acuity Based of the Opto-Kinetic Nystagmus. William Schumann, O.D., Vineland, New Jersey.

Cataract and Its Etiology. Arthur Schlaifer, Ph.D., Pennsylvania State College of Optometry.

The Use of Statistics in Visual Research. Francis A. Young, Ph.D., Washington State College.

The annual formal Round Table Dinner will take place Monday night. A complete program will appear in the November issue. Dr. John D. Perry, Jr., is Chairman of the Papers and Program Committee.

COMMITTEE ON ADMITTANCE

The Committee on Admittance, Dr. Harold Simmerman, Chairman, will meet on December 4, at Chicago, to examine those candidates whose Case Reports have been approved.

THE EXECUTIVE COUNCIL

The Executive Council, Dr. Meredith W. Morgan, Jr., Chairman, will be in session December 3-4, in Chicago, to conclude the routine business of the Academy for the year and to go over the last minute arrangements for the annual meeting. The Council will also hold several regular meetings during the four-day sessions December 5-8, to confer with members on problems or questions needing Academy attention. Members wishing to present material or to confer with the Executive Council should now arrange appointments through the office of the Secretary.

SHEARD COMMEMORATIVE VOLUME—PROGRESS REPORT

In June of this year the American Academy of Optometry invited the *friends of Sheard* in optometry, ophthalmology and opticianry to participate in celebrating the 70th birthday of Dr. Charles Sheard, noted educator and scientist.

In his honor it was proposed to publish, in a Sheard Commemorative Volume, many of his early papers on refractive subjects and ophthalmic optics. To be included were monographs which formed much of the scientific background for many of the tests used today in refracting. Most of this original material is now out of print. An outline of the many papers to appear in the Sheard Commemorative Volume has already been printed.

The initial editorial work on these selected papers is now being done by Dr. Charles Sheard at his home in Rochester, Minnesota, and the text when completed will form the content of a special cloth bound book of from 300 to 400 pages.

In addition, this Commemorative Volume will contain the names of the *friends of Sheard* who subscribed to a special fund of $8,000.00 needed to properly do the job. Subscriptions in amounts of from $10 to $25 are invited from all of the *friends of Sheard* in optometry, ophthalmology and opticianry. Each subscriber will receive a prepaid copy of the Commemorative Volume when printed.

During September the committee members working to raise the necessary funds from the *friends of Sheard* to publish the Sheard Commemorative Volume made splendid progress. On September 25 the optometric committee working on the project had secured 296 pledges for a total of $5,102.50 and had some promises of additional subscriptions not reported in the above totals.

A preliminary report by Leslie W. Myers for the opticianry

committee indicates that the *friends of Sheard* among opticians have already secured 90 pledges for a total of slightly more than $1,400.00. Here, too, the fund raising work will continue.

Some additional subscriptions from the *friends of Sheard* among the physicians and ophthalmologists are also reported coming in.

The campaign has now passed the three-quarter mark and is on the home stretch. Many additional subscriptions are needed to raise the necessary total of $8,000.00. All readers are urged to send in their check—for from $10 to $25 to the "Sheard Fund — American Academy of Optometry," 1502 Foshay Tower, Minneapolis 2, Minnesota.

The time to identify yourself with this outstanding Commemorative project is now. The book will make a real contribution to the literature on refraction and the problems of binocular vision. In addition it will have lasting sentimental value. If you have not already done so—send in your contribution today, and join us in making the Sheard Commemorative Volume the success it so richly deserves.

CAREL C. KOCH

BOOK NOTICES

CONTACT LENS ROUTINE AND PRACTICE. Norman Bier. Published by Butterworths Scientific Publications, London, England, and by the C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Missouri. 188 pages, 105 illustrations. Cloth bound. 1953. $6.

The aim of this book is the presentation of a routine for fitting contact lenses as developed in the author's own practice. No attempt is made to reiterate material adequately covered in other works. In particular, the molding technique and the optics of contact lenses have been omitted; the Haptic fit has been treated only in those respects where amplification to more modern developments has rendered this necessary. Detailed treatment has been given to ventilated, sealed minimum-clearance and corneal lenses. Of special note are the skillfully devised photographs which demonstrate visually the details discussed in the text.

This book is an excellent addition to the available literature on contact lenses. Its value chiefly stems from the compilation of recommendations and suggestions of the author to the design and fitting of the newest types of lenses.

Without doubt, the author's qualifications are unique. He has been a well-known contact lens practitioner for many years and a

pioneer in the development and use of the ventilated lenses. His writings have been extensive. The fact that the author again in this book is willing to share freely and without stint his wide experience and knowledge certainly is a wonderful testimony to the man.

This book is recommended to anyone interested in the fitting and use of contact lenses. In particular, it is suggested for reading by practitioners with some background and as a reference textbook for students commencing their study of this comparatively new form of ophthalmic correction.

V. J. ELLERBROCK.

EYE-STRAIN, ITS CAUSE, CONSEQUENCES AND TREATMENT. V. Brumer. Published by the Victor Optical Company, Lancashire, England. 128 pages. Glossary. Cloth. 1953. Price 9/6.

The author is correct in stating that "the therapeutics of lens treatment outlined in this book forms no part of contemporary medical practice." He could also have added that the views expressed do not cohere to any part of the existing body of science.

Brumer believes that practically all disease, including such anomalies as myopia, is bound up somehow with leakage of "Life-Force." "Eye-strain" is one source of leakage. "There is not a single disease symptom, which cannot be mitigated by the prevention of uncontrolled visual functioning." He grudgingly admits that "the so-called wonder drugs . . . may have a short-term significance in dealing with certain types of bacteria," but their value is limited as compared with "Oculo-Neuro-Therapy." "The consultant in command of this technique is able to bring about a redistribution of Life-Force within the organism and thereby its direct application to the weakest point indicating its symptoms." (As this quotation indicates, Brumer could have utilized the services of a good editor. The sentence structure sometimes becomes extremely confused.)

Thus the author brings to its "logical" conclusion the doctrines of our native optometric cults. This is strictly unrecommended reading.

WILLIAM F. GARBER

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AVAILABLE MONOGRAPHS

The American Academy of Optometry has available a limited number of reprints of the following original papers. These monographs, printed with special board covers, will be mailed, postpaid, to professionally interested persons upon receipt of order, and the cost of reprint. Selection should be made by number. American Academy of Optometry, 1502 Foshay Tower, Minneapolis 2, Minn.

- ☐ Monograph No. 78. Readiness and Emotional Problems Associated with Reading Disabilities. Wilmot F. Schneider. 16 p. + cover. Price 35c.
- ☐ Monograph No. 79. Orthoptics Specification by a Graphical Method. Henry W. Hofstetter. 8 p. + cover. Price 25c.
- ☐ Monograph No. 80. Applications of Psychological Principles in Optometric Practice. Alfred Lit. 16 p. + cover. Price 35c.
- ☐ Monograph No. 82. An Objective High Speed Photographic Technique for Simultaneously Recording Changes in Accommodation and Convergence. Merrill J. Allen. 12 p. + cover. Price 30c.
- ☐ Monograph No. 83. Clinical Indications for Prescribing Prisms—With Three Case Reports. Rudolph T. Textor. 12 p. + cover. Price 30c.
- ☐ Monograph No. 84. A Comparison of Peripheral Stereoscopic and Visual Acuities. V. J. Ellerbrock. 8 p. + cover. Price 25c.
- ☐ Monograph No. 85. Balancing Visual Stimuli in Orthoptic Training. Matthew Luckiesh, R. M. Hall and S. K. Guth. 8 p. + cover. Price 25c.
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- ☐ Monograph No. 87. The A. M. A. Method of Appraisal of Visual Acuity. Henry W. Hofstetter. 12 p. + cover. Price 30c.
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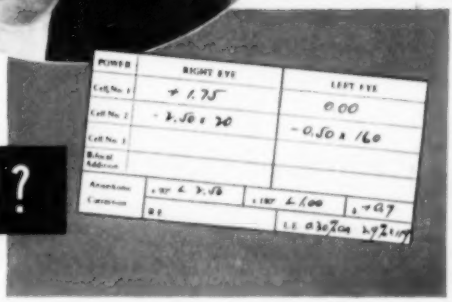
PRESCRIPTION?



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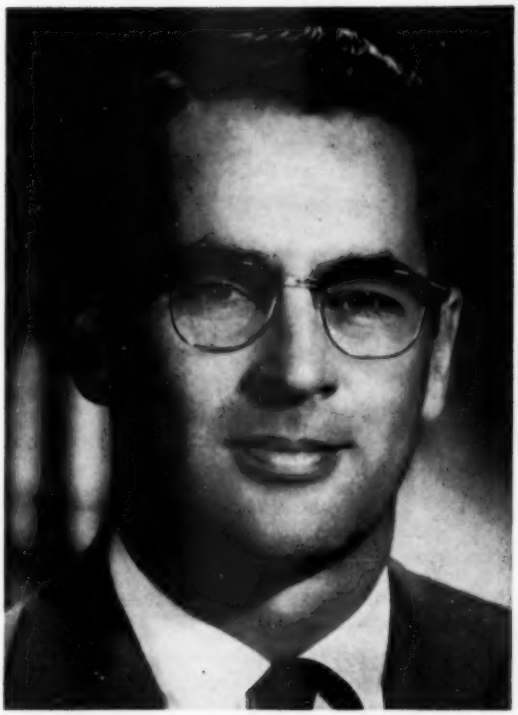

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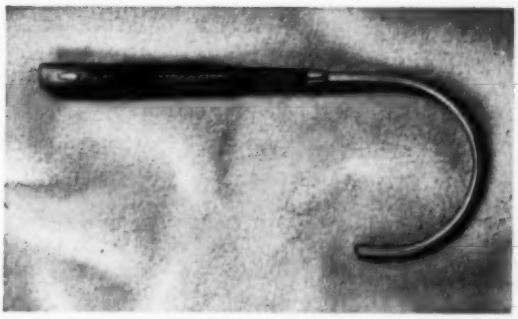

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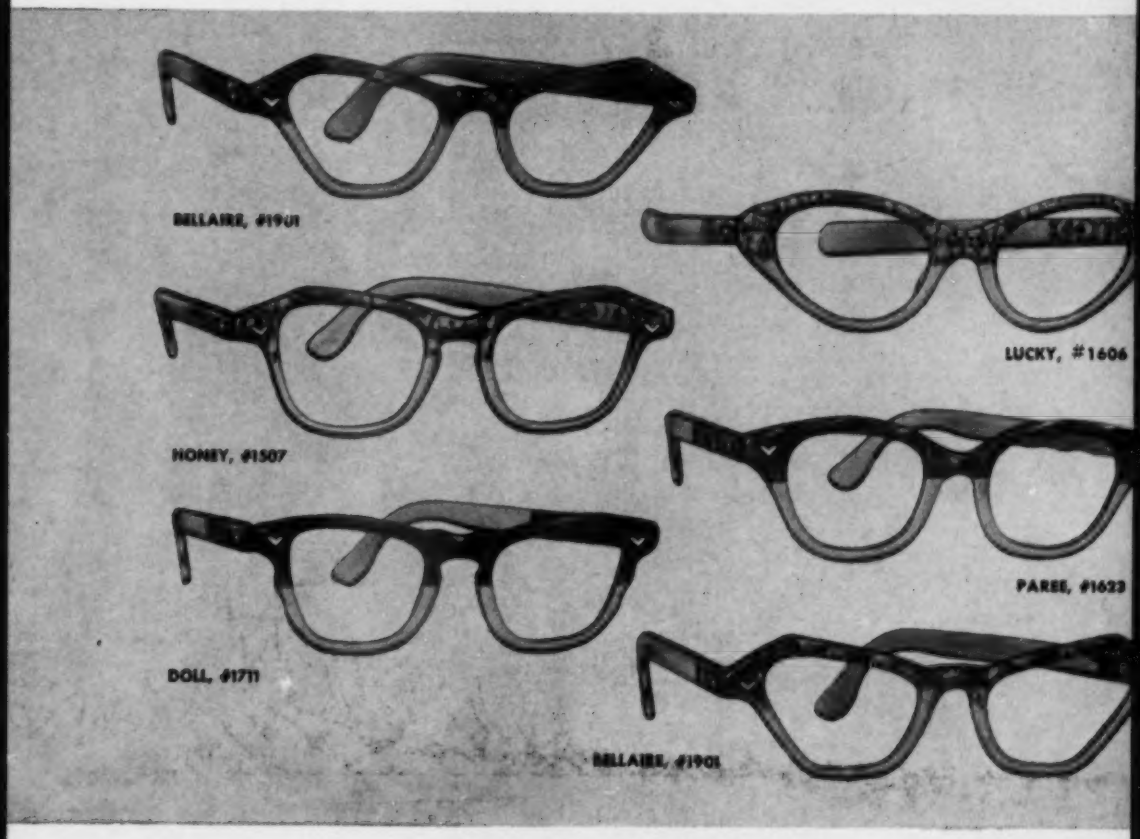

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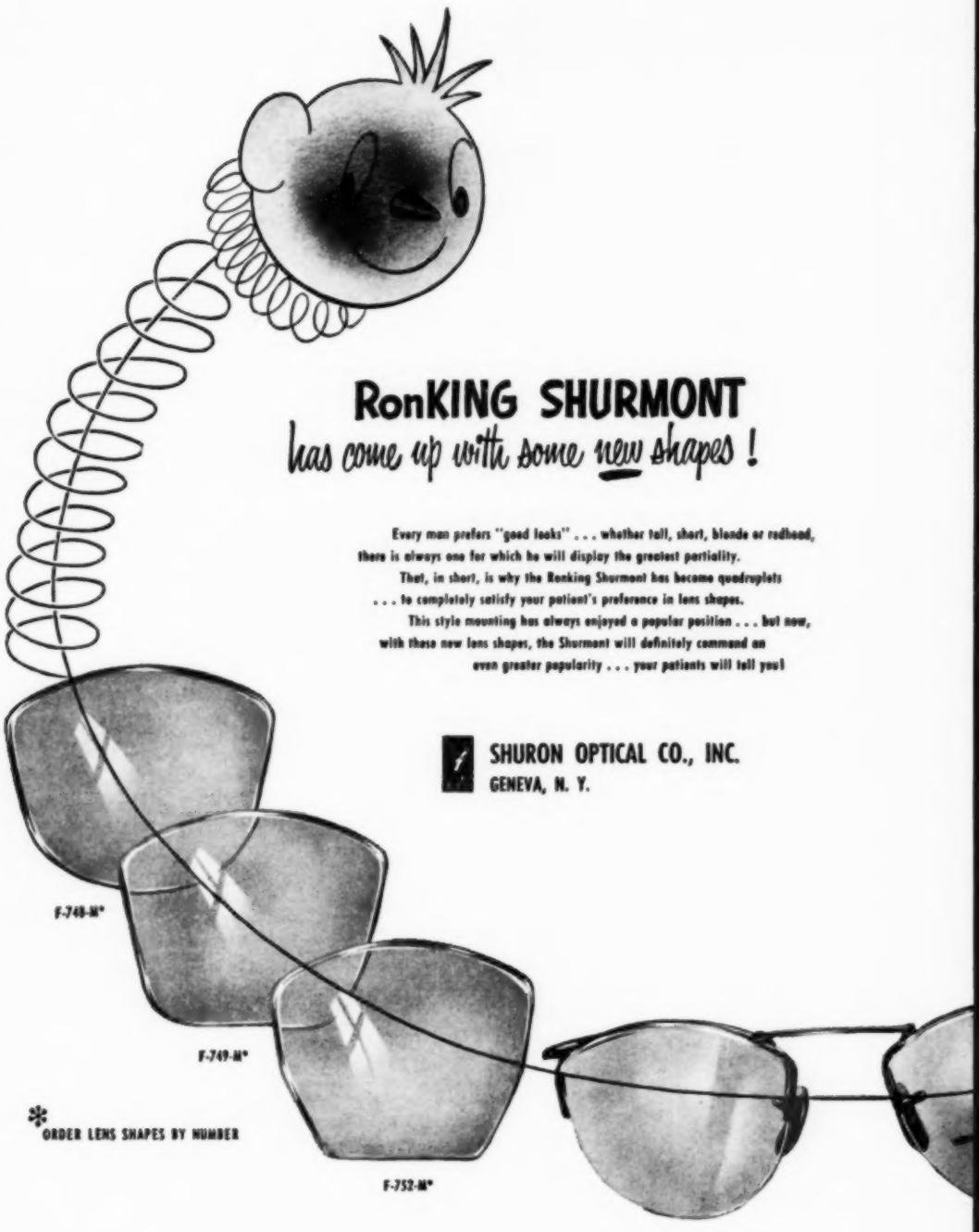

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